NewFields

Expert Report
of
Shahrokh Rouhani, Ph.D., P.E.

In the United States District Court for the Eastern District of Missouri
A.O.A., et al. v. The Doe Run Resources Corporation, et al. Civil Action No. 4:11-cv-00044-CDP (consolidated) (E.D. Mo)

S. Rouhani

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March 19, 2021

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1 INTRODUCTION

1 As discussed in my November 2019 report, I have been retained by King & Spalding LLP on behalf of its clients The Renco Group, Inc., D.R. Acquisition Corp., Doe Run Cayman Holdings, LLC, Ira L. Rennert, The Doe Run Resources Corporation, Theodore P. Fox, III, Marvin M. Kaiser, Albert Bruce Neil, and Jeffrey L. Zelms (collectively, "Defendants") in connection with *A.O.A., et al. v. Doe Run Resources Corp., et al.*, Civil Action No. 4:11-cv-00044-CDP (consolidated) (E.D. Mo). The case revolves around the environmental impacts from the *Complejo Metalúrgico de La Oroya* (CMLO) smelter and refinery operations managed by Doe Run Peru (DRP) between 1997 and 2009.

2 On December 1, 2020, Mr. David A. Sullivan and Dr. Jack Matson submitted reports to replace those previously submitted by Dr. Nicholas Cheremisinoff, whom I understand passed away. I incorporate fully herein my November 2019 report, including the opinions contained therein and the bases, therefore.

3 This supplementary report presents my statistical review and opinions on the reliability of claims presented in Mr. Sullivan's supplementary report, dated December 1, 2020. I also considered Mr. Sullivan's rebuttal report, dated June 22, 2020 submitted on behalf of the Plaintiffs related to the CMLO smelter and refinery operations during DRP ownership.

4 Mr. Sullivan's supplementary report presents three model runs, hereinafter referred to as:

(a) *Sullivan-Cheremisinoff*: Mr. Sullivan's prior model runs based on Dr. Cheremisinoff's prior emission treatment,

(b) *Sullivan-McVehil*: Mr. Sullivan's model runs purportedly based on Dr. McVehil's emission treatment, and

(c) *Sullivan-Sullivan*: Mr. Sullivan's new model runs based on his own emission treatment as set forth in his supplementary report.

Mr. Sullivan concludes that these three model runs are "*generally consistent*" (Sullivan 2020b, p. 26). Mr. Sullivan provides no quantitative or statistical evidence to back up his conclusion. These comparisons, and Mr. Sullivan's claim that the models are consistent, especially with regards to Dr. McVehil's results, appear to be intended to demonstrate the reliability of Mr. Sullivan's model runs.

5 My review of Mr. Sullivan's supplementary and rebuttal reports found several statistical flaws that render his presented results devoid of any technical credibility and his opinions based on those results invalid and unreliable. My findings are summarized by the following opinions:

- Opinion 1: The Sullivan-McVehil model runs are misrepresentations of Dr. McVehil's modeling results.

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- Opinion 2: Mr. Sullivan's air models yield statistically biased and unreliable predictions under <u>any</u> of his presented emission treatment scenarios.

- Opinion 3: Mr. Sullivan's claim about the general consistency of his three model runs is misleading and unsubstantiated.

6 I reserve the right to revise and/or supplement my opinions as additional information is provided or acquired. These opinions may also be supplemented to rebut the opinions expressed by other experts in this litigation. I hold all the opinions expressed in this report to a reasonable degree of scientific certainty.

2 EXPERIENCE/QUALIFICATIONS/TRAINING/EDUCATION

7 My experience and qualifications are set forth in my November 2019 report. A summary of my experience and education is also provided in Section 8. My compensation and past witness information are provided in Sections 6 and 7, respectively.

3 INFORMATION RELIED UPON

8 In addition to my training, experience, and general knowledge of environmental and statistical principles, I have reviewed and analyzed the materials identified in my November 2019 report, as well as the datasets relied upon by Plaintiffs' experts, and relevant documents provided to me by King & Spalding. Section 5 provides the list of cited references.

9 The sources of my statistical analyses, presented in Attachments A through F, are Excel files which were produced by Mr. Sullivan as part of the reliance material of his recent supplementary report (Sullivan 2020b), including:

- Sullivan-Cheremisinoff, Sullivan-Sullivan, and Measured Daily Lead and Arsenic: MODELING/NEW-COMPOSITE-RUN/MODEL-PERFORMANCE-ADJ-HEIGHT(2.5H)-(LEAD-ARSENIC).xlsx
- Sullivan-McVehil Daily Lead: MODELING/MC-VEHILL-NO-BUILDING/MODEL-PERFORMANCE-ADJ-HEIGHT(2.5H)-(LEAD-ARSENIC).xlsx
- Sullivan-Cheremisinoff, Sullivan-Sullivan, and Measured Hourly SO_2: MODELING/NEW-COMPOSITE-RUN/MODEL-PERFORMANCE-ADJ-HEIGHT(2.5H)-(SO2- PM10).xlsx
- Sullivan-McVehil Hourly SO_2: MODELING/MC-VEHILL-NO-BUILDING/MODEL-PERFORMANCE-ADJ-HEIGHT(2.5H)-(SO2- PM10).xlsx

10 All statistical analyses presented herein are conducted in *RStudio*[1] with codes provided separately. Additional data sources are identified in appropriate footnotes.

[1] www.rstuido.com

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4 OPINIONS

11 I reached my opinions after reviewing Mr. Sullivan's supplementary and rebuttal reports submitted on behalf of the Plaintiffs related to CMLO smelter and refinery operations during DRP ownership. This section contains discussions of my opinions.

4.1 Opinion 1: The Sullivan-McVehil model runs are misrepresentations of Dr. McVehil's modeling results.

12 In his rebuttal report, Mr. Sullivan repeatedly refers to the fact that Defendants' experts consider Dr. McVehil's earlier air model results as reliable (Sullivan 2020a, p. 4; p. 22; p. 68; p. 78). As part of his rebuttal, Mr. Sullivan allegedly "re-ran" Dr. McVehil's modeling work by taking the DRP fugitive emission estimates used by Dr. McVehil and running those through Mr. Sullivan's constructed model. Mr. Sullivan concluded, on the basis of that effort, that "*the bottom-line results of* [Dr. McVehil's] *modeling at the locations* [Dr. McVehil] *modeled are quite similar to mine* [Sullivan's model results] (Sullivan 2020a, p. 32)." My review indicates that Mr. Sullivan's unsubstantiated statement is misleading and inaccurate.

13 Mr. Sullivan reported the results of his so-called "McVehil model" in Table A-2 of his rebuttal report (Sullivan 2020a, p. 58). Hereinafter these model runs are referred to as the Sullivan-McVehil model results. Lead results were reported as:

Table 1. Mr. Sullivan's Table A-2: Run 2 – McVehil Emission Treatment
ORIG LEAD RESULTS correspond to Sullivan-Cheremisinoff results
NEW LEAD RESULTS correspond to Sullivan-McVehil results

	ORIG LEAD RESULTS		NEW LEAD RESULTS	
SITE	2007		2007	
	MODELED	MEASURED	MODELED	MEASURED
INCA	1.02	1.27	0.87	1.27
CUSH	-	-	-	-
HUAN	1.92	6.47	0.16	6.47
CASA	0.08	0.42	0.21	0.42
MARC	0.21	1.03	0.23	1.03
HUAR	0.08	0.77	0.09	0.77
SIND	5.11	2.09	2.93	2.09
HUAY	0.10	0.45	0.25	0.45

14 In his supplementary report, submitted in December 2020, Mr. Sullivan presents another set of "re-run" results of the Sullivan-McVehil model as he did previously in his rebuttal report. However, as I explain below, these results differ markedly from the results Mr. Sullivan presented in his rebuttal report. These data are presented in Table E-6 of his supplementary report (Sullivan 2020b, p. 16):

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Table 2. Mr. Sullivan's Table E-6: Comparison of PM10 Modeling Based on Cheremisinoff Emission Treatments with Modeling Based on Using the Emission Treatments from Dr. McVehil's Modeling Analysis for Lead and SO2
CHEREMISINOFF LEAD correspond to Sullivan-Cheremisinoff results
MCVEHIL LEAD correspond to Sullivan-McVehil results

	CHEREMISINOFF LEAD		MCVEHIL LEAD	
SITE	2007		2007	
	MODELED	MEASURED	MODELED	MEASURED
INCA	1.02	1.27	0.64	1.27
CUSH	-	-	-	-
HUAN	1.92	6.47	0.96	6.47
CASA	0.08	0.42	0.08	0.42
MARC	0.21	1.03	0.17	1.03
HUAR	0.08	0.77	0.08	0.77
SIND	5.11	2.09	5.92	2.09
HUAY	0.10	0.45	0.10	0.45

15 Notice that while the results of Sullivan-Cheremisinoff model and measured results have remained unchanged, the Sullivan-McVehil results (identified within red boxes) have been substantially altered between Mr. Sullivan's earlier rebuttal results and those presented in his subsequent supplementary report.

- The earlier Sullivan-McVehil's "re-run" results in Mr. Sullivan's rebuttal report matched measured values closer than those attributed to the Sullivan-Cheremisinoff model.
- The subsequent Sullivan-McVehil "re-run" results in Mr. Sullivan's supplementary report, however, were as poor estimators of the measured values as those reported by the Sullivan-Cheremisinoff.
- For example, the earlier Sullivan-McVehil "re-run" in Mr. Sullivan's rebuttal report at Sindicato Station was within 40% of the measured value, while the subsequent reported value in Mr. Sullivan's supplementary report was more than 180% over-estimated.[2]

Mr. Sullivan does not provide any explanation for the dramatic alterations in his Sullivan-McVehil's "re-run" results. Mr. Sullivan's silence is especially alarming considering that his more recent McVehil "re-run" results are clearly less accurate than his earlier McVehil results. Mr. Sullivan neither explains, nor justifies his modeling changes resulting in less accurate results. Failing to provide adequate explanation casts serious doubt on the technical reliability of Mr. Sullivan's unsubstantiated claims.

16 In his supplementary report, Mr. Sullivan claims that he is reproducing Dr. McVehil's earlier modeling results (Sullivan 2020b, p.9). The question that immediately arises is: Are the results of the Sullivan-McVehil model unbiased reproductions of Dr. McVehil's actual model results? To

[2] The reported lead Sindicato results in Mr. Sullivan's supplementary report are derived from his Sullivan-McVehil model with "no building." The alternative Sullivan-McVehil model re-run "with building" generates a lead Sindicato concentration that is even further different from the measured value when compared to his "no building" result. So clearly the difference between the reported Sullivan-McVehil results in his rebuttal and supplementary reports cannot be attributed to the "no building" vs. "with building" scenarios.

answer this question, I reviewed Dr. McVehil modeling results at various locations and time periods (MMA 2008a; 2008b). I then compared these results to the Sullivan-McVehil model results, as listed in Tables 3 and 4 below. Additional comparisons based on lead and SO_2 results at various locations and time periods are provided in Attachment A.

Table 3. Comparison of Dr. McVehil's Annual (March 2007 – February 2008) Results to Sullivan-McVehil Results

Station	Statistic	McVehil Model[1]	Sullivan - McVehil[2]	% Difference[3]
Hotel Inca	Annual Average Lead (μg/m³)	1.16	0.43	-63%
Sindicato		2.19	2.83	+29%
Huanchan		1.96	0.80	-59%
Casaracra		0.03	0.05	+70%
Marcavalle		0.53	0.12	-77%
Hotel Inca	Annual Max Lead (μg/m³)	2.8	2.47	-12%
Sindicato		5.1	16.31	+220%
Huanchan		16.9	3.57	-79%
Marcavalle		1.9	0.55	-71%
1) Source: MMA (2008a) (Ref 151, Appendix B, pdf p. 58) & MMA (2008b) (Ref 113, Table 6.1, p. 30)				
2) Source: "MC-VEHILL-NO-BUILDING\MODEL-PERFORMANCE-ADJ-HEIGHT(2.5H)-(LEAD-ARSENIC).xlsx"				
3) % Difference = (Sullivan-McVehil – McVehil)/McVehil				

Table 4. Comparison of Dr. McVehil's Monthly Average Lead (μg/m³) at Sindicato Station to Sullivan-McVehil Results

Month Year	McVehil	Sullivan-McVehil	% Difference
March 2007	1.74	1.69	-3%
April 2007	1.21	2.50	+107%
May 2007	0.85	2.29	+170%
June 2007	0.75	2.50	+233%
July 2007	0.77	1.21	+57%
August 2007	0.77	1.48	+92%
September 2007	0.87	1.36	+56%
October 2007	1.55	4.54	+193%
November 2007	1.27	7.30	+475%
December 2007	1.68	NA	-
January 2008	1.93	2.62	+36%
February 2008	1.63	4.02	+147%

17 The above tables clearly indicate that the Sullivan-McVehil model produces substantially different predictions than those actually reported by Dr. McVehil. These large differences can be as high as +475% or more than 4 times higher than Dr. McVehil's reported results. These findings led me to the conclusion that Mr. Sullivan's so-called "McVehil" model re-runs are biased misrepresentations of Dr. McVehil's original model results.

4.2 Opinion 2: Mr. Sullivan's air models yield statistically biased and unreliable predictions under any of his presented emission treatment scenarios.

18 The results of any air model should be assessed against measured values to determine its reliability. USEPA (1978, Section 6.0 Model Validation/Calibration, p. 39) states: "*Any application of an air quality model may have deficiencies which cause estimated concentrations to be in error. When practical to obtain a measure of confidence in the estimates, they should be compared with observed air quality and their validity determined*." Given the abundance of measured air quality values at various stations in the La Oroya area, such a determination is both feasible and practical. In fact, Dr. McVehil (MMA 2008a, 2008b) subjected his model to several statistical evaluations to validate and calibrate his reported results to the extent practical. These included inspections of quantile-quantile (Q-Q) plot of predicted versus measured results, as well as analyses of computed Fractional Bias, Absolute Fractional Bias, Root Mean Square Error, and Average Bias. Mr. Sullivan, however, fails to subject his model results to any rigorous form of validation or calibration.[3]

19 **Nonconcurrent Comparisons:** As noted in USEPA (2017, p. 5209), errors in model input can result in concentration errors: "Such uncertainties do not indicate that an estimated concentration does not occur, only that the precise time and locations are in doubt. Composite errors in highest estimated concentrations of 10 to 40 percent are found to be typical." Given this fact, I conducted nonconcurrent comparisons between Mr. Sullivan's predicted and measured values. Nonconcurrent comparisons apply a chemical-specific averaging scheme that does not require measured and modeled values to be synchronous. For example, in the year 2007, the maximum measured annual 3-month rolling average of air lead at Sindicato occurred during the October-December 2007 period, while the Sullivan-Sullivan model predicted the maximum rolling average occurring 9 months earlier during January-March 2007. In this work, nonconcurrent comparisons use the maximum annual 3-month rolling average for lead, the annual average for arsenic, and the annual 99th percentile of the daily 1-hour maximum for SO_2 (Sullivan 2019, p. 68).

20 Figure 1 below compares Mr. Sullivan's nonconcurrent predicted lead concentrations versus the measured lead concentrations at various stations under different emission treatment scenarios. Each plot includes a 1:1 black dashed line (perfect agreement between predicted and measured values), as well as red dashed lines representing ±40% margins of error. The same results are listed in Table 5 below. Results associated with arsenic and SO_2 concentrations are provided in Attachment B.

[3] Mr. Sullivan interprets a statement in USEPA (2017, p. 5209) about regulatory applications of air models to claim that "*calibration is not allowed in U.S.* (Sullivan 2020a, p. 25)."

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Figure 1. Nonconcurrent Comparison of Mr. Sullivan's Predicted 3-Month Maximum Lead Values vs. Measured Values

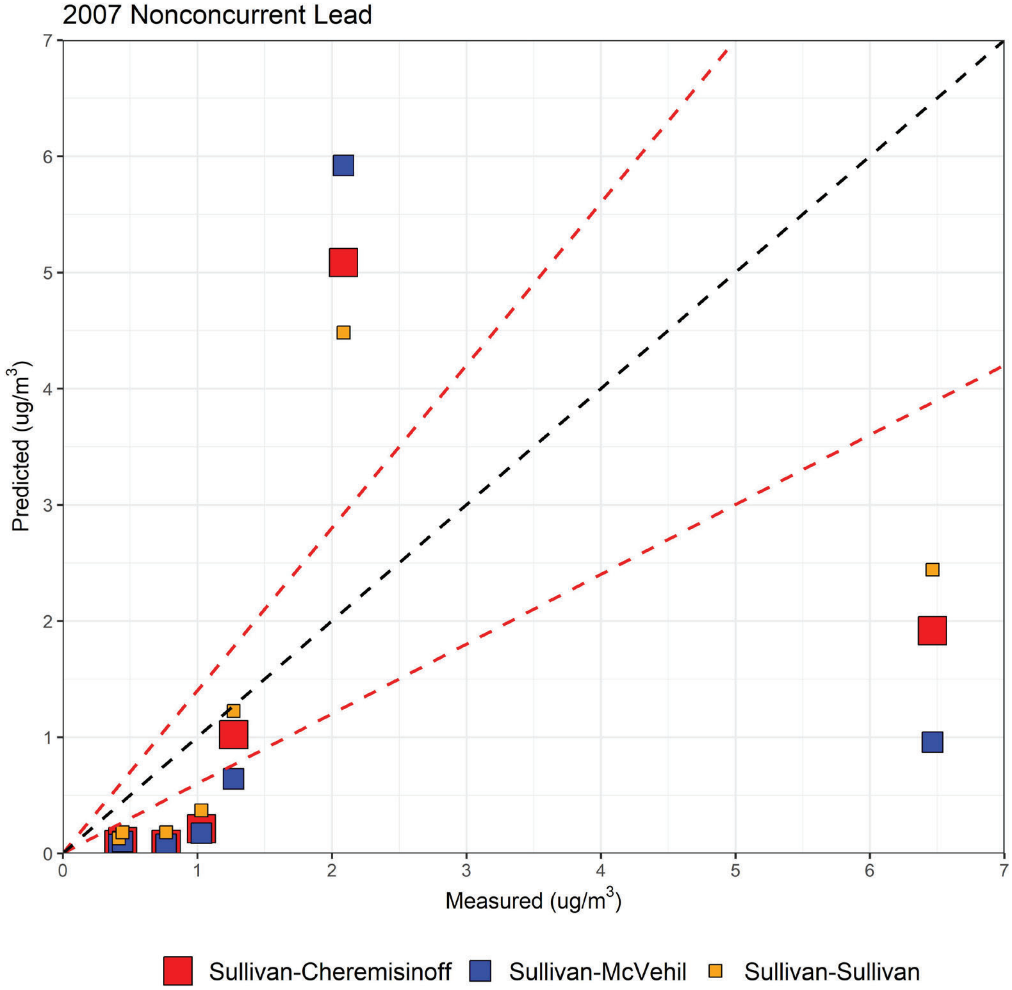

Table 5. Nonconcurrent Comparison of Mr. Sullivan's Predicted 3-Month Maximum Lead Values vs. Measured Values ($\mu g/m^3$)

% Difference = (Predicted – Measured)/Measured

Highlighted values exceed 40% difference between predicted value and measured value.

Station	Measured	Sullivan-McVehil		Sullivan-Cheremisinoff		Sullivan-Sullivan	
		Predicted	% Difference	Predicted	% Difference	Predicted	% Difference
INCA	1.27	0.64	-50%	1.02	-20%	1.23	-4%
HUAN	6.47	0.96	-85%	1.92	-70%	2.44	-62%
CASA	0.42	0.08	-82%	0.08	-82%	0.13	-69%
MARC	1.03	0.17	-83%	0.21	-79%	0.37	-64%
HUAR	0.77	0.08	-90%	0.08	-90%	0.18	-76%
SIND	2.09	5.92	+184%	5.08	+144%	4.48	+115%
HUAY	0.45	0.10	-77%	0.10	-77%	0.18	-59%

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21 These results indicate that the vast majority of predicted values generated by Mr. Sullivan in his various modeling efforts — even using noncurrent comparisons — are outside of the USEPA's 40% typical margin of error (USEPA 2017, p. 5209). Therefore, regardless of the emission treatment scenario, Mr. Sullivan's models produce inaccurate results. Furthermore, Mr. Sullivan's models display systematic biases by overestimating concentrations at the Sindicato Station, while underestimating concentrations at all other stations. These results clearly demonstrate the unreliability of Mr. Sullivan's model under any of his emission treatment scenarios.

22 **Concurrent Comparisons:** The above nonconcurrent comparisons can mask the inherent biases and weaknesses of Mr. Sullivan's predictive models. Therefore, a comprehensive evaluation of his models must include the comparison of predicted values against their contemporaneous measured values, hereinafter referred to as concurrent comparisons. Mr. Sullivan's models predict daily air lead and arsenic concentrations and hourly SO_2 concentrations at specific locations. These predictions are generated on granular time and space units that can be compared to their concurrent measured values. Such concurrent comparisons provide more reliable and straightforward assessments of Mr. Sullivan's models than those produced by nonconcurrent comparisons.

23 Figure 2 below displays the results of the Sullivan-Sullivan model's predicted daily lead values on the Y-axis against their concurrent measured values on the X-axis. Each point represents a modeled and measured value during the same day. This simple comparison can be used to evaluate the reliability of Mr. Sullivan's models. The diagonal black dashed line indicates a 1:1 slope, or 100% accurate model. Red-dashed lines present ±50% prediction errors.[4] Points falling outside of these prediction errors do not meet the "*factor of two*" agreement Mr. Sullivan cites as a measure of model reliability (EPA 2008, p. 8). The computed R-squared[5] and p-value[6] of model vs. measured values are also reported. The right panel presents the same model vs. measured data for individual stations. Together these performance plots reveal both systematic and station-specific biases in either over-estimations or under-estimations of measured values. Additional results associated with arsenic and SO_2 concentrations are provided in Attachment C.

[4] The ±50% prediction error is consistent with Mr. Sullivan's Reference 152 (EPA 2002, p. 8), which states: "*For model evaluation studies, a factor of two agreement between modeled and observed values is generally considered to be acceptable*."

[5] R-squared is a measure of linear correlation between two variables. R-squared is considered as a measure of goodness-of-fit of a predictive model relative to measured values. R-squared varies between 0 and 1, with 1 indicating a perfect (100%) match between predicted and measured values, and 0 indicating absence of any linear correlation between predicted values and measured values.

[6] p- value represents the likelihood that zero correlation exists between the measured and predicted variables. Often in environmental statistics, when p-value falls below 5%, the relationship is said to be statistically significant, i.e., the observed relationship cannot be attributed to chance. Note that a model is a reliable predictor only if the R-squared is large (typically greater than 0.5) with a p-value less than or equal to 5%.

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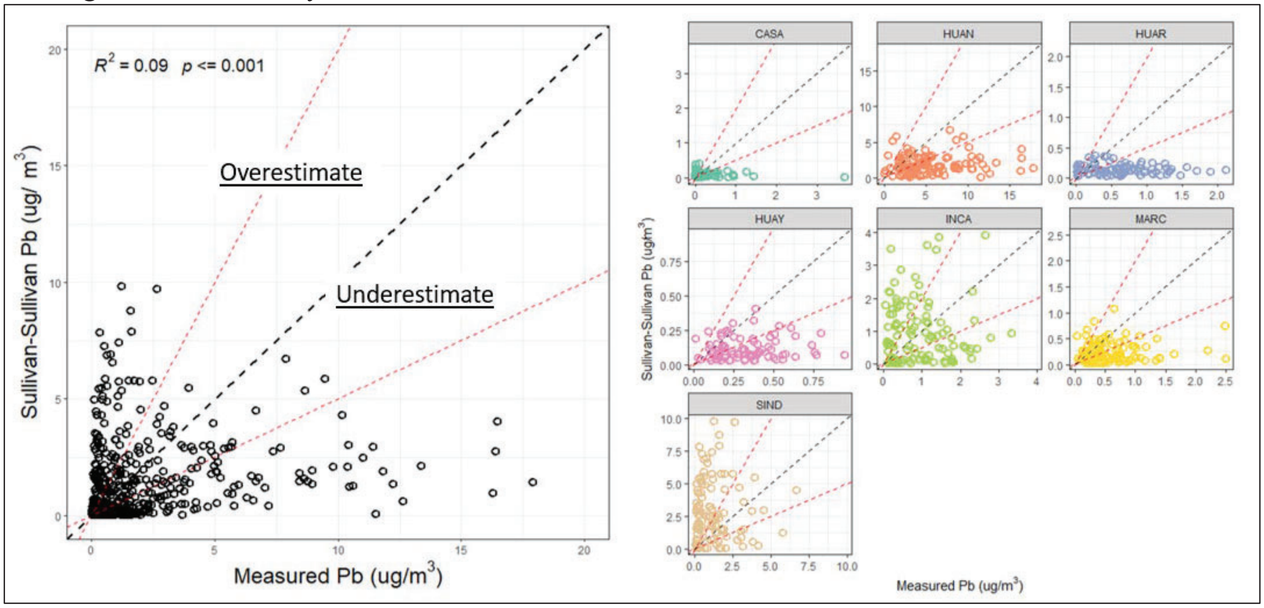
Figure 2. 2007 Daily Concurrent Lead Sullivan-Sullivan Predicted vs. Measured Values[7]



24 The above figure displays the comparison of lead concentrations predicted by the Sullivan-Sullivan model versus their corresponding measured values. Attachment C contains similar comparisons of lead, arsenic, and SO_2 concentrations for all of Mr. Sullivan's emission treatment scenarios. These comprehensive results reveal the following deficiencies of Mr. Sullivan's models:

- **Highly unreliable results:** Regardless of the modeled emission treatment scenario[8] and chemical[9], Mr. Sullivan's model predictions display extremely weak correlation to their corresponding measured values. In this case, R-squared is the measure of linear correlation between Mr. Sullivan's predicted values versus their corresponding measured values. R-squared varies between 0 and 1, with 1 indicating that 100% of variations in measured values are explained by the model results, and 0 indicating none of the variations in measured values are explained by the model results. As noted in USEPA (1978, p. 42): "*… if the model accounts for less than 50 percent of the variation of measured concentrations, it is doubtful that there is justification for using the model*." The R-squared of Mr. Sullivan's models consistently fall well below the USEPA 50% threshold, which highlights the general unreliability of his model predictions.
- **Poor predictors:** Regardless of emission treatment scenario, most of Mr. Sullivan's model predictions fail the factor-of-two agreement with their measured values, and thus, are poor predictors. In fact, in the above figure, more than 75% of the predicted lead concentrations by the Sullivan-Sullivan model when compared to their corresponding measured values fail to meet the factor-of-two agreement.

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[7] Source: 2020.12.08 Sullivan Production - Reliance Materials/MODELING/NEW-COMPOSITE-RUN/MODEL-PERFORMANCE-ADJ-HEIGHT(2.5H)-(LEAD-ARSENIC).xlsx" [Daily-Lead - PM10 - 2007].

[8] Evaluated models with different emission treatment scenarios included the Sullivan-Sullivan, the Sullivan-Cheremisinoff, and the Sullivan-McVehil (No Building) models. See Attachment C for detailed concurrent reliability results.

[9] Evaluated chemicals included lead, arsenic, and SO_2. See Attachment C for detailed concurrent reliability results.

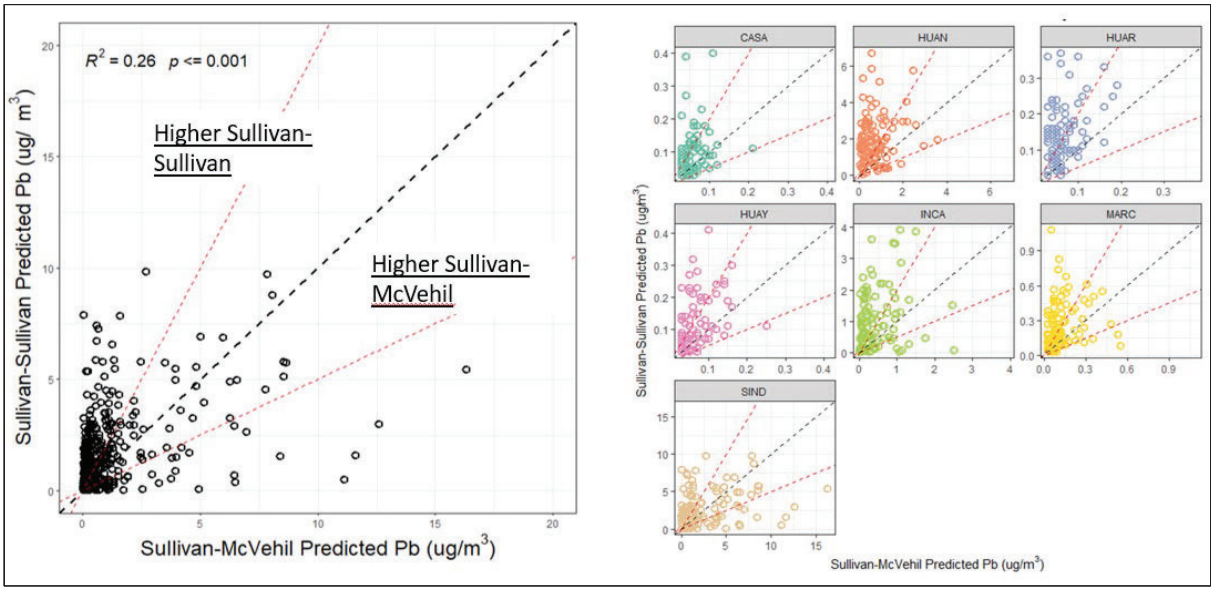
- **Systematic spatial bias:** Regardless of emission treatment scenario, Mr. Sullivan's models display systematic spatial bias. As the station-specific plots to the right in Figure 1 indicate, Mr. Sullivan's model results tend to systematically overestimate the measured values at Sindicato Station, while systematically underestimating measured values in other stations.

25 The above findings lead me to the conclusion that Mr. Sullivan's models produce biased and unreliable results regardless of their corresponding emission treatment scenarios and temporal averaging schemes.

4.3 Opinion 3: Mr. Sullivan's claim about the general consistency of his three model runs is misleading and unsubstantiated.

26 Mr. Sullivan in his supplementary report (Sullivan 2020b, p. 26) claims that: "In a composite sense, all three modeling approaches are generally consistent with the Defendants' measured air quality data for lead and SO_2." This claim is repeated throughout his supplementary report (Sullivan 2020b, p.9, 26, 27). Mr. Sullivan, however, fails to provide any statistical evidence in support of his claim. Using information provided by Mr. Sullivan, however, I compared his predicted model results versus each other. An example is shown in Figure 3 below, which displays predicted daily lead based on the Sullivan-McVehil model versus those predicted by the Sullivan-Sullivan model. The plot to the left is the scatter plot of predicted values based on the two emission treatment scenarios, along with the computed R-squared (R^2), the 1:1 black dashed line, as well as red dashed lines displaying the ±50% differences. Points falling outside of the dashed lines are more than a factor-of-two different. The panel to the right presents the same scatter plots for each specific station. Additional comparisons between Mr. Sullivan's models under different emission treatments are provided in Attachment D.

Figure 3. Comparison of 2007 Concurrent Daily Lead Predictions Based on Sullivan-Sullivan vs. Sullivan-McVehil Model Runs



27 The comparison of Mr. Sullivan's model predicted values under different emission treatment scenarios reveals:

- **Weak correlations:** Mr. Sullivan's model predictions under different emission treatment scenarios display weak correlations, yielding R-squared falling well below the 0.5 level.[10]
- **Poor agreements:** Most of Mr. Sullivan's model predictions based on different emission treatment scenarios are more than 50% different. For example, in the above figure, 67% of lead concentrations predicted by the Sullivan-Sullivan model are more than ±50% different than their corresponding predicted values by the Sullivan-McVehil model. Thus, fully two-thirds of Mr. Sullivan's model results fail the factor-of-two reliability test that Mr. Sullivan himself cites.
- **Systematic spatial biases:** Mr. Sullivan's model predictions based on different emission scenarios display systematic biases at various stations. For example, as displayed in Figure 3, the Sullivan-Sullivan model produces higher estimates than the Sullivan-McVehil model at all stations except Sindicato.

28 The above comparisons revealed substantial differences between Mr. Sullivan's model predictions under various emission treatment scenarios. These findings led me to the conclusion that Mr. Sullivan's claim of the "general consistency" of his model runs is misleading and unsubstantiated.

4.4 Summary and Conclusions

29 Upon a thorough review of Mr. Sullivan's cited reports, I reached the following conclusions:

- Opinion 1: Sullivan-McVehil model runs are misrepresentations of Dr. McVehil's modeling results.

- Opinion 2: Mr. Sullivan's air models yield statistically biased and unreliable predictions under <u>any</u> of his presented emission treatment scenarios.

- Opinion 3: Mr. Sullivan's claim about the general consistency of his three model runs is misleading and unsubstantiated.

5 REFERENCES

Bianchi-Mosquera, G. C. (2014). Expert opinion of Gino Bianchi Mosquera, D. Env., P.G. concerning certain environmental issues associated with the La Oroya Metallurgical Complex, Junin, Peru.

Connor, J.A. (2019). Expert opinion of John A. Connor, P.E., P.G., BCEE concerning environmental conditions at La Oroya Metallurgical Complex, Junin, Peru.

McVehil-Monnett Associates, Inc. (MMA 2008a). Final Summary Report Air Quality Dispersion Modeling for La Oroya (Sullivan Ref 151 Appendix B, pdf p. 58)

McVehil-Monnett Associates, Inc. (MMA 2008b). Final Complimentary Report, Air Quality Dispersion Modeling for La Oroya. (Sullivan Ref 113).

Sullivan, D.A. (2019). Air Quality & Meteorological Analysis of the Doe Run Peru Smelter and Refinery Operations in the Vicinity of La Oroya, Peru.

[10] In my experience, 0.5 is used as a threshold between a weak and strong correlation.

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Sullivan, D.A. (2020a). Rebuttal: Dr. Libicki, Dr. Rouhani, and Mr. Hoffnagle Expert Reports. June 22, 2020.
Sullivan, D.A. (2020b). Review of Emissions and Release Specifications for the La Oroya Metallurgical Complex. December 1, 2020.
Sullivan, D.A. (2021). Deposition of David Sullivan, A.O.A., et al. Vs. Doe Run Resources Corporation, et al., 4:11-cv-00044-CDP (E.D.Mo January 19, 2021).
USEPA. (1978). Guideline on Air Quality Models. EPA-450/2-78-027.
USEPA. (2002). Example Application of Modeling Toxic Air Pollutants in Urban Areas. EPA-454/R-02-003. (Sullivan Ref. 152).
USEPA. (2017). Revisions to the Guideline on Air quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches to Address Ozone and Fine Particulate Matter. 82 FR 5182. (Sullivan Ref. 143).

6 COMPENSATION

30 My compensation rates are set forth in my November 2019 report.

7 OTHER WITNESS INFORMATION

31 My other witness information is set forth in my November 2019 report.

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8 CURRICULUM VITAE

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Internet Mail:srouhani@newfields.com

EDUCATIONAL BACKGROUND

Ph.D.	1983	Harvard University	Environmental Sciences
S.M.	1980	Harvard University	Engineering
B.A.	1978	University of California, Berkeley	Economics
B.S.	1978	University of California, Berkeley	Civil Engineering

PROFESSIONAL EXPERIENCE

President	NewFields Companies, LLC	1995 - Present
Editorial Board Member	*Environmental Forensics* Association for Environmental Health and Sciences	2003 - Present
Adjunct Professor	School of Civil and Environmental Engineering Georgia Institute of Technology	1996 - 2004
Associate Professor	School of Civil and Environmental Engineering Georgia Institute of Technology	1990 - 1996
Senior Consultant	Dames & Moore Atlanta, GA	1990 - 1995
Chairman	National Ground Water Hydrology Committee, Hydraulics Division, American Society of Civil Engineers	1991 - 1992
Expert Member	ASTM/EPA/USGS/DOD Geostatistics Standardization Committee	1991 - 1998
Associate Editor	*Water Resources Research* American Geophysical Union	1989 - 1994
Assistant Professor	School of Civil Engineering Georgia Institute of Technology	1983 - 1990
Chairman	Task Committee on Geostatistical Techniques in Geohydrology, American Society of Civil Engineers	1987 - 1989
National Science Foundation Visiting Scientist	*Centre de Géostatistique, Ecole Nationale Supérieure des Mines de Paris*, France	1987 - 1988

PROFESSIONAL REGISTRATION

Licensed Professional Engineer	Georgia (Registration Number 19369)

CURRENT FIELD OF INTEREST

Geostatistics
Environmental Statistics
Geostatistical and Stochastic Hydrology
Decision Analysis
Groundwater and Surface Hydrology

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HONORS AND AWARDS

Tau Beta Pi (National Engineering Honor Society)	1977
Chi Epsilon (Civil Engineering Honor Society)	1978
Phi Beta Kappa (National Honor Society for Students in Social Sciences)	1978
Watson Award, Division of Applied Sciences, Harvard University	1979-82
Sigma Chi (Scientific Research Society)	1987
1990 Who's Who (Rising Young Americans)	1990
ASCE Task Committee Excellence Award, Hydraulics Division (S. Rouhani, Chairman of ASCE Task Committee on Geostatistical Techniques in Geohydrology)	1991
Dictionary of International Biography - 22nd Edition	1992
Two Thousand Notable American Men, First Edition	1992
Who's Who in America	1995-Present

REPRESENTATIVE PROJECT EXPERIENCE

Government Sector Sample Projects

NOAA Assessment of Deepwater Horizon MC252 Oil Impacts – Principal investigator for development of statistical sampling designs and conducting statistical analyses for various shoreline technical working groups as part of NRDA evaluation.

United Nations Compensation Commission Expert Assessment **–** Extensive sediment and soil data provided associated with the environmental damages from post-1991 Kuwait conflict were statistically and geostatistically analyzed. These analyses were conducted as part of the UNCC technical review of submitted claims.

US EPA Project on Multivariate Geostatistical Trend Detection and Network Design for Acid Deposition Data– Principal investigator for development of a multivariate geostatistical technique for trend detection in acid deposition data and spatial evaluation of current national network, known as NAPD/NTN.

US EPA Project on Statistical Source Contamination Identification, Coleman-Evans Superfund Site, Whitehouse, FL – On behalf of EPA, extensive historical soil data were analyzed in order to determine the extent of ambient versus site-related dioxins.

US EPA Project on Statistical Source Contamination Identification, ACW Superfund Site, Pensacola, FL – On behalf of EPA, extensive historical soil data were analyzed in order to determine the extent of ambient versus site-related dioxins.

US EPA Guidance for Soil Cleanup Strategies – Principal author on geostatistical procedures for optimal soil cleanup delineation.

US Navy CURT (Clean Up Review Team) – Technical lead on strategic review of US Navy environmental restoration projects worldwide. In this role Dr. Rouhani assisted US Navy to review more than 750 projects and identify more than $100 million in cost-avoidance.

US Navy Mole Pier, San Diego Naval Station, CA – Project director for the data evaluation and analysis of the anticipated $40 million dollar clean-up project.

US Navy Allen Harbor Landfill, North Kingstown, RI – Project director for updating superfund remedy selection. The original cap remedy cost was estimated at $14 million.

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US Navy, Cecil Field, Naval Air Station Jacksonville, FL – Project director for the geostatistical analysis of lead soil data at a former firing range. This project was later selected by the US EPA as a case study for an upcoming guidance document on optimal soil remedy selection at CERCLA sites.

US Navy, Mountain Creek Lake, NWIRP Dallas, TX – Principal investigator for the sediment background analysis. This innovative study led to an expedited approval of sediment delineation, while avoiding a potentially expensive and time-consuming ecological risk assessment.

US Navy RITS Lectures and CECOS Classes – Principal lecturer at US Navy Remediation Innovative Technology Seminar (RITS), as well as a regular lecturer at CECOS courses on Environmental Background Analysis, Navy Environmental Restoration Program, and Environmental Sampling Design and Data Quality Assessment.

US Department of Energy Project on Application of Geostatistical Methods to Savannah River Site Environmental and Geotechnical Investigation, SC – Principal investigator for development and application of advanced procedures for evaluation of the adequacy of groundwater quality data at a waste site, as well as development of geostatistical estimation/simulation procedure in support of seismic modeling of the site.

South Florida Water Management District, US Sugar Land Acquisition, FL – Developed and negotiated the approval of statistical procedures for due diligent sampling and analysis process, conducted the statistical analysis of due diligent soil samples, developed confirmatory sampling and analysis process, and participated in technical discussions and negotiations.

St. Johns River Water Management District Minimum Flow Determination, FL – Developed an innovative combined hydrodynamic and statistical approach to establish minimum flow levels for Blue Spring based on protection of manatees winter refuge criteria.

St. Johns River Water Management District Geostatistical Peer Review, FL – Lead technical reviewer for numerous projects at SJRWMD, including optimization of groundwater monitoring networks, mapping of potentiometric surfaces, groundwater flow modeling, assessment of seagrass monitoring protocols, Lake Apopka soil data analysis, and time series analysis of groundwater and lake monitoring data.

South Florida Water Management District Lower West Coast Potentiometric Mapping, FL – Technical lead on statistical and geostatistical analysis of available seasonal, multi-layer groundwater elevation data for Lower West Coast potentiometric Mapping.

<u>Private Sector Sample Projects</u>

Anniston Lead Site, Anniston, AL – Lead negotiation, cleanup, and sampling efforts at Anniston Lead Site, Alabama. These efforts included statistical and geostatistical analyses of soil lead and PCB data in order to verify the extents of zones of investigations.

Alabama Wood Treaters Site, Mobile, AL – Principal investigator concerning a legal dispute on cost recovery. This project involved analysis of an extensive list of historical documents and aerial photographs.

RFI Investigation, Middlesex, NJ – Principal investigator for soil arsenic background data analysis. This project involved compilation and analysis of large historical datasets for determining arsenic background concentrations.

Geostatistical Source Impact Delineation, Mission Valley, San Diego, CA – Extensive BTEX, MTBE groundwater database was geostatistically analyzed in order to define the extent of site-related plumes.

Groundwater statistical optimization, Athens, GA – Assessment of soil and groundwater at manufacturing facility in Athens, Georgia. Geostatistics was used to (1) characterize the groundwater contamination in a three-dimensional framework, and (2) identify areas which figure either data gaps, or potentially elevated contaminations. Geostatistically produced kriged and quantile maps were used to characterize the site contamination, as well as identify location for subsequent sampling activities.

EXHIBIT 1

Statistical Risk Evaluation, Detroit, MI – Principal investigator for risk assessment study of a major development site. Geostatistics were used to estimate surface soil block contamination, evaluate the adequacy of the existing surficial measurements, and design an information-efficient deep soil sampling plan.

Soil Characterization Planning and Optimization, Charleston, SC – An innovative phased geostatistical sampling plan was developed to characterize soil and groundwater contamination at a RCRA industrial site in South Carolina.

Groundwater Transport Modeling for Remedial Evaluation, Atlanta, GA – Determined the effectiveness of a proposed list of groundwater remedial alternatives at a CERCLA site through the use of U.S. Geological Survey groundwater flow/transport model, MOC-2D. The results of the model provided a realistic assessment of long-term potential efficiency of the various pump-and-treat alternatives.

Risk Evaluation of Contaminated Sites in Michigan – Existing soil data from an abandoned industrial site in Michigan were geostatistically analyzed to perform two tasks: (1) to characterize the site contamination in a multi-layer framework, and (2) identify areas which figure either data gaps, or potentially elevated contaminations.

Spatial Statistical Assessment, Baton Rouge, LA – Performed an extensive soil and groundwater analysis at a CERCLA site in Baton Rouge, Louisiana. Site was geostatistically analyzed in order to perform four major tasks: (1) to characterize three-dimensional soil contamination mapping, (2) to calculate block-area groundwater contamination levels, (3) to produce sampling plans for subsequent measurements, and (4) to provide the most accurate information on the spatial distribution of Analytes of the groundwater flow/transport model of the site.

Data Analysis at a Former Refinery, Peñuellas, Puerto Rico – Principal investigator for the compilation and analysis of available soil and groundwater, as part of a RCRA Facility Investigation.

Statistical Assessment of Migration Potential, Memphis, TN – Principal investigator for the geostatistical analysis of existing data on the thickness of a critical near-surface aquitard to determine zones of potential leakage to the lower aquifer.

GEORGIA TECH REPRESENTATIVE STATISTICAL RESEARCH EXPERIENCE

Title:	Optimal Sampling of Stochastic Processes
Sponsor:	National Science Foundation
Duration:	(6/1/85 to 10/30/87)
Subject:	In this project, Dr. Rouhani developed optimal sampling and monitoring techniques for ground water quantity and quality investigations, based on advanced geostatistical procedures. It was shown that using such techniques can yield economically efficient sampling plans.

Title:	Optimal Schemes for Ground Water Quality Monitoring in the Shallow Aquifer, Dougherty Plain, Southwestern Georgia
Sponsor:	U.S. Geological Survey
Duration:	(4/1/86 to 3/31/87)
Subject:	In this project, Dr. Rouhani developed a flexible geostatistical procedure for planning a ground water quality monitoring network in Dougherty Plain, Georgia. The proposed network acts as a warning system for the protection of the Floridian Aquifer system which is a major source of water in south Georgia and Florida.

Title:	Advanced Geostatistical Studies at the Centre de Geostatistique, Ecole des Mines de Paris.
Sponsor:	National Science Foundation
Duration:	(9/1/87 - 2/18/89).
Subject:	Through this project Dr. Rouhani developed new techniques for statistical analysis of space-time data, including air pollution and ground water contamination data. The budget of this project was the highest amount awarded by the NSF's "U.S. - Industrialized Countries Program for the Exchange of Scientists and Engineers" in 1987.

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Title: Geostatistical Evaluation of Flow Analytes
Sponsor: U.S. Geological Survey
Duration: (4/1/90 - 3/31/91)
Subject: Dr. Rouhani developed techniques for efficient estimation of ground water flow Analytes based on available hydrogeological field data.

Title: Multivariate Geostatistical Trend Detection and Network Design for Acid Deposition Data
Sponsor: U.S. Environmental Protection Agency
Duration: (3/1/1991 -9/30/1991)
Subject: Dr. Rouhani developed a multivariate geostatistical technique for trend detection in acid deposition data and spatial evaluation of current national network, known as NAPD/NTN.

Title: Multilayer Geostatistical Ground Water Flow and Transport Modeling
Sponsor: HazLab, Inc.
Duration: (6/20/92 -12/30/92)
Subject: Dr. Rouhani developed a combined deterministic/geostatistical groundwater flow/transport model.

Title: Velocity/Lithology Model Database, Statistical Models of Soil Columns Velocity, and Maps of Model Layers
Sponsor: Westinghouse Savannah River Company / U.S. DOE
Duration: (1/1/1993-6/30/1993)
Subject: Dr. Rouhani developed a relational database and conducted extensive geostatistical analyses of seismic data.

Title: Application of Geostatistical Methods to SRS Groundwater Monitoring and Environmental Risk
Sponsor: Westinghouse Savannah River Company / U.S. DOE
Duration: (7/1/1993-10/15/1993)
Subject: Dr. Rouhani developed procedures for evaluation of the adequacy of groundwater quality data at a waste site.

Title: H-Area/ITP Geostatistical Assessment of In-situ and Engineering Properties
Sponsor: Westinghouse Savannah River Company / U.S. DOE
Duration: (1/1/1994-6/30/1995)
Subject: Dr. Rouhani will develop geostatistical estimation/simulation procedure in support of seismic modeling of the site.

PUBLICATIONS

Published Books and Parts of Books

1. Rouhani, S., and T.J. Hall, "Geostatistical Schemes for Groundwater Quality Management in Southwest Georgia," in Pollution, Risk Assessment, and Remediation in Groundwater Systems, pp. 197-223, R.M. Khanbilvardi and J. Fillos, Eds., Scientific Publications Co., Washington, DC, 1987.
2. Rouhani, S., and R. Kangari, "Landfill Site Selection," in Expert Systems: Applications to Urban Planning, Ch. 10, T.J. Kim *et al.*, Eds., Springer-Verlag, 1989.
3. Lennon, G.P., and S. Rouhani, Eds., Ground Water, Proceedings of the ASCE International Symposium on Ground Water, ASCE, 1991.
4. Rouhani, S., R. Srivastava, A. Debarats, M. Cromer, and I. Johnson, Eds., “Geostatistics for Environmental and Geotechnical Applications,” STP 12 83, ASTM, 1996.
5. Wellington, B., and Rouhani S., “Environmental Statistics,” in Sustainable Land Development and Restoration: Decision Consequence Analysis, pp. 311-323, K. Brown *et al.*, Eds., Butterworth-Heinemann, New York, NY, 2010.

6. Uhler, A.D., Stout, S.A., Emsbo-Mattingly, S.D., and Rouhani S., “Chemical Fingerprinting: Streamlining Site Assessment during the Sustainable Redevelopment Process,” in Sustainable Land Development and Restoration: Decision Consequence Analysis, pp. 311-323, K. Brown *et al.*, Eds., Butterworth-Heinemann, New York, NY, 2010.

Standards and Guidance Documents (Main Author/Contributing Author)

1. American Society of Testing and Materials (ASTM), Standard Guide for Reporting Geostatistical Site Investigations, D5549-94, 1994.
2. American Society of Testing and Materials (ASTM), Standard Guide for Analysis of Spatial Variation in Geostatistical Site Investigations, D5922-96, 1996.
3. American Society of Testing and Materials (ASTM), Standard Guide for Selection of Kriging Methods in Geostatistical Site Investigations, D5923-96, 1996.
4. American Society of Testing and Materials (ASTM), Standard Guide for Selection of Simulation Approaches in Geostatistical Site Investigations, D5924-96, 1994.
5. ASTM International, Standard Guide for Determination of Representative Sediment Background Concentrations, E3242 – 20, 2020.
6. Department of Navy (DON), Guidance for Environmental Background Analysis, Volume I: Soil, NFESC User’s Guide, UG-2049-ENV, April 2002.
7. Department of Navy (DON), Guidance for Environmental Background Analysis, Volume II: Sediment, NFESC User’s Guide, UG-2054-ENV, April, 2003.
8. Department of Navy (DON), Guidance for Environmental Background Analysis, Volume III: Groundwater, NFESC User’s Guide, UG-2059-ENV, April, 2004.
9. Department of Navy (DON), Guidance for Environmental Background Analysis, Volume IV: Vapor Intrusion Pathway, User’s Guide, UG-2091-ENV, Interim Final, April 2011.
10. United States Environmental Protection Agency (US EPA), *Guidance for Soil Cleanup Strategies*, Draft, 2003.

Published Journal Papers (refereed)

1. Rouhani, S., "Variance Reduction Analysis", *Water Resources Research*, Vol. 21, No. 6, pp. 837-846, June, 1985.
2. Rouhani, S., "Comparative Study of Ground Water Mapping Techniques", *Journal of Ground Water*, Vol. 24, No. 2, pp. 207-216, March-April 1986.
3. Rouhani, S., and Fiering, M.B., "Resilience of a Statistical Sampling Scheme," *Journal of Hydrology*, Vol. 89, No. 1, pp. 1-11, December, 1986.
4. Rouhani, S., and Kangari, R., "Landfill Site Selection: A Microcomputer Expert System," *International Journal of Microcomputers in Civil Engineering*, Vol. 2, No. 1, pp. 29-35, March, 1987.
5. Rouhani, S., and Hall, T.J., "Geostatistical Schemes for Groundwater Sampling," *Journal of Hydrology*, Vol. 103, 85-102, 1988.
6. Rouhani, S., and Cargile, K.A., "A Geostatistical Tool for Drought Management," *Journal of Hydrology*, Vol. 106, 257-266, 1989.
7. ASCE Task Committee on Geostatistical Techniques in Geohydrology (S. Rouhani, Chairman and Principal Author), "Review of Geostatistics in Geohydrology, 1. Basic Concepts," *ASCE Journal of Hydraulic Engineering*, 116(5), 612-632, 1990.
8. ASCE Task Committee on Geostatistical Techniques in Geohydrology (S. Rouhani, Chairman and Principal Author), "Review of Geostatistics in Geohydrology, 2. Applications," *ASCE Journal of Hydraulic Engineering*, 116(5), 633-658, 1990.
9. Rouhani, S., and H. Wackernagel, "Multivariate Geostatistical Approach to Space-Time Data Analysis," *Water Resources Research*, 26(4), 585-591, 1990.
10. Rouhani, S. and D.E. Myers, "Problems in Space-Time Kriging of Geohydrological Data," *Mathematical Geology*, 22(5), 611-624, 1990.
11. Loaiciga, H.A., R.J. Charbeneau, L.G. Everett, G.E. Fogg, B.F. Hobbs, and S. Rouhani, "Review of Ground-Water Quality Monitoring Network Design," *ASCE Journal of Hydraulic Engineering*, 118(1), 11-37, 1992.
12. Rouhani, S., R. Ebrahimpour, I. Yaqub, and E. Gianella, "Multivariate Geostatistical Trend Detection and Network Evaluation of Space-Time Acid Deposition Data, 1. Methodology," *Atmospheric Environment*, 26A(14), 2603-2614, 1992.
13. Rouhani, S., R. Ebrahimpour, I. Yaqub, and E. Gianella, "Multivariate Geostatistical Trend Detection and Network Evaluation of Space-Time Acid Deposition Data, 2. Application to NADP/NTN Data," *Atmospheric Environment*,

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26A(14), 2615-2626, 1992.

14. Casado, L., S. Rouhani, C. Cardelino, and A. Ferrier, "Geostatistical Analysis and Visualization of Hourly Ozone Data," *Atmospheric Environment*, 28(12), 2105-2118, 1994.
15. Rouhani, S., Geostatistical Estimation: Kriging, in Rouhani *et al.*, Eds., "*Geostatistics for Environmental and Geotechnical Applications*," STP 12 83, ASTM, 1996.
16. Wild, M. R., and S. Rouhani, Effective Use of Field Screening Techniques in Environmental Investigations: A Multivariate Geostatistical Approach, in Rouhani *et al.*, Eds., "*Geostatistics for Environmental and Geotechnical Applications*," STP 12 83, ASTM, 1996.
17. Lin, Y. P., and S. Rouhani, "Geostatistical Analyses for Shear Wave Velocity," *J. of The Geological Society of China*, Vol. 40, No. 1, p 209-223, 1997.
18. Lin, Y.P., and S. Rouhani, "Multiple-Point Variance Analysis for Optimal Adjustment of A Monitoring Network," *Environmental Monitoring and Assessment*, 69(3), pp. 239-266, 2001.
19. Lin, Y. P., Y. C. Tan, and S. Rouhani, "Identifying Spatial Characteristics of Transmissivity Using Simulated Annealing and Kriging Methods," *Environmental Geology*, 41:200-208, 2001.
20. Lin, Y. P., H.J. Chu, Y.L. Huang, C.H Tang, and S. Rouhani, "Monitoring and Identification of Spatiotemporal Landscape Changes in Multiple Remote Sensing Images by Using a Stratified Conditional Latin Hypercube Sampling Approach and Geostatistical Simulation," *Environmental Monitoring Assessment*, 177:353–373, 2011.
21. Zengel, S., C. L. Montague, S. C. Pennings, S. P. Powers, M. Steinhoff, G. Fricano, C. Schlemme, M. Zhang, J. Oehrig, Z. Nixon, S. Rouhani, and J. Michel, "Impacts of the Deepwater Horizon Oil Spill on Salt Marsh Periwinkles (Littoraria irrorata)," *Environ. Sci. Technol.*, 50(2): 643-652, 2016.
22. Willis, J. M., M. Hester, S. Rouhani, M. Steinhoff, M. Baker, "Field Assessment of the Impacts of Deepwater Horizon Oiling on Coastal Marsh Vegetation of Mississippi and Alabama," *Environmental Toxicology and Chemistry*, (ETCJ-Nov-15-00911.R1), 2016.
23. Nixon, Z., S. Zengel, M. Baker, M. Steinhoff, G. Fricano; S. Rouhani, J. Michel, "Shoreline Oiling from the Deepwater Horizon Oil Spill," *Marine Pollution Bulletin*, (MPB-D-15-01195), 2016.
24. Hester, M. W., J. M. Willis, S. Rouhani, M. A. Steinhoff, and M. C. Baker. Impacts of the Deepwater Horizon oil spill on the salt marsh vegetation of Louisiana. *Environmental Pollution*, 216: 361-370, 2016 https://doi.org/10.1016/j.envpol.2016.05.065
25. Stout, S. A., S. Rouhani, B. Liu, J. Oehrig, R. W. Ricker, G. Baker, C. Lewis. Assessing the Footprint and Volume of Oil Deposited in Deep-Sea Sediments following the Deepwater Horizon Oil Spill. *Marine Pollution Bulletin*. 114:327-342. 2016.
26. Rouhani, S., M. C. Baker, M. Steinhoff, M. Zhang, J. Oehrig, I. J. Zelo, S. D. Emsbo-Mattingly, Z. Nixon, J.
27. M. Willis, and M. W. Hester. Nearshore Exposure to Deepwater Horizon Oil. *Marine Ecology Progress Series*. 576: 111–124, 2017. https://doi.org/10.3354/meps11811
28. Kenworthy, W. J., N. Consentino-Manning, L. Handley, M. Wild, S. Rouhani. Seagrass response following exposure to Deepwater Horizon oil in the Chandeleur Islands, Louisiana (USA). *Marine Ecology Progress Series*. 576: 145–161, 2017. https://doi.org/10.3354/meps11983
29. Gibbs, J. P., S. Rouhani, L. Shams. "Frog and Toad Habitat Occupancy across a Polychlorinated Biphenyl (PCB) Contamination Gradient." *Journal of Herpetology*. 51(2):209-214. 2017.
30. Gibbs, J. P., S. Rouhani, L. Shams. "Population status of freshwater turtles across a PCB contamination gradient." *Aquatic Biology*. 26: 57-68. 2017.
31. Gibbs, J. P., S. Rouhani, L. Shams. "Scale-dependence in polychlorinated biphenyl (PCB) exposure effects on waterbird habitat occupancy." *Ecotoxicology*, 26(6):762-771, 2017.
32. Grabowski. J.H., S.P. Powers, H. Roman, and S. Rouhani. "Potential impacts of the 2010 Deepwater Horizon Oil Spill on subtidal oysters in the Gulf of Mexico." *Marine Ecology Progress Series*. 576:163-174, 2017.
33. Powers, S.P., S. Rouhani, M.C. Baker, H. Roman, J.H. Grabowski, J.M. Willis, and M.W. Hester. "Loss of fringing oyster habitat as a result of the Deepwater Horizon Oil Spill degrades nearshore ecosystems." *Marine Ecology Progress Series*. In press. 2017.
34. Douglas, G., J. Hardenstine, S. Rouhani, D. Kong, R. Arnold, and W. Gala. "Chemical Preservation of Semi-volatile Polycyclic Aromatic Hydrocarbon Compounds at Ambient Temperature: A Sediment Sample Holding Time Study." *Archives of Environmental Contamination and Toxicology*. https://doi.org/10.1007/s00244-018-0517-y. March 2018.
35. Geiselbrecht, A., S. Rouhani, K. Thorbjornsen, D. Blue, S. Nadeau, T. Gardner-Brown, and S. Brown. "Important Considerations in the Derivation of Background at Sediment Sites." *Integrated Environmental Assessment and Management*. DOI 10.1002/ieam.4124. 2019.

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Published Research Reports

1. Rouhani, S., "Toward a More Efficient Farm Level Models," presented at the seminar on water management planning in Pakistan, Development Research Center, World Bank, Washington, DC, Ford-Pakistan Project Annual Progress Report, 1980.
2. Chaudri, A., S. Rouhani and P.P. Rogers, "Hydrology of Induced Recharge in Indus Basin Pakistan," Department of City and Regional Planning, Harvard University, 1980.
3. Rouhani, S., "Toward a More Effective Indus Basin Model, Waterlogging and Salinity Considerations," presented at the Tri-partite meeting in Pakistan, Development Research Center, world Bank, Washington, DC, Ford-Pakistan Project Annual Progress Report, 1981.
4. Rouhani, S. and T. J. Hall, "Optimal Schemes for Ground Water Quality Monitoring in the Shallow Aquifer, Dougherty Plain, Southwestern Georgia," Technical Completion Report, U.S. Dept. of Interior/USGS Project G-1219(05), ERC 05-87, Environmental Resources Center, Georgia Institute of Technology, Atlanta, Georgia, 49 p., 1987.
5. Rouhani, S., "Optimal Sampling of Stochastic Processes," Final Technical Research Report, National Science Foundation, Grant No. ECE-8503897, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia, p. 170,1987.
6. Rouhani, S., "*L'Analyse de Donnees Geohydrologiques*," De Geostatisticis, No. 3, pp. 5-6, August, 1988.
7. Rouhani, S., "Advanced Geostatistical Studies at the Centre de Geostatistique, Ecole des Mines de Paris," Final Technical Research Report, National Science Foundation, Grant No. INT-8702264, School of Civil Engineering, Georgia Institute of Technology, Atlanta, GA, 129 p., May 1989.
8. Rouhani, S., "Geostatistics: Theory, Practice, and Personal Computer Applications," Education Extension, Georgia Institute of Technology, September, 1989.
9. Rouhani, S., R. Ebrahimpour, I. Yaqub, and E. Gianella, "Multivariate Geostatistical Trend Detection and Network Evaluation of Space-Time Acid Deposition Data," Final Technical Report, AREAL, U.S. Environmental Protection Agency, Contract 68-D0-0095, RTP, NC, 320 p., October, 1991.
10. Rouhani, S., M. J. Maughon, and B. J. Weiss, "Geostatistical Mapping of Ground Water Contaminants," Technical Report, HazLab, Inc., Contract E-20-X18, School of Civil Engineering, Georgia Institute of Technology, Atlanta, January 1993.

Conference Papers (refereed)

1. Rouhani, S., "Optimal Groundwater Data Collection, Waterlogging and Salinity Considerations," *Proceedings of the International Seminar on Water Resources Management*, Lahore, Pakistan, No. 3, pp. 167-182, October 1983.
2. Rouhani, S., "A Scheme for Water Resources Monitoring in Rural Areas," *Proceedings of the Vth World Congress on Water Resources*, IWRA, Vol. 2, pp. 701-710, June, 1985.
3. Kangari, R. and Rouhani, S., "Expert Systems in Reservoir Management and Planning," in *World Water Issues in Evolution, Water Forum '86*, M. Karamouz et al., Eds., Vol. 1, pp. 186-194, American Society of Civil Engineers, New York, 1986.
4. Rouhani, S., and R. Kangari, "Expert Systems in Water Resources," *Water for the Future: Hydrology in Perspective*, J. C. Rodda and N.C. Matalas, Eds., pp. 457-462, International Association of Hydrological Sciences, Publication No. 164, 1987.
5. Rouhani, S., and T.J. Hall, "Space-Time Kriging of Groundwater Data," in *Geostatistics*, M. Armstrong, Editor, Vol. 2, pp. 639-650, Kluwer Academic Publishers, Dordrecht, Holland, 1989.
6. Kangari, R., and Rouhani, S., "Knowledge-Based Systems in Water Resources Management," *Proceedings of the International Conference on Water and Wastewater*, pp. 588-593, Academic Periodical Press, Beijing, China, 1989.
7. Rouhani, S., "Geostatistics in Water Resources," *Proceedings of the 1989 Georgia Water Resources Conference*, K. J. Hatcher, Ed., pp. 169-171, Institute of Natural Resources, University of Georgia, Athens, Georgia, 1989.
8. Rouhani, S., and M. E. Dillon, "Geostatistical Risk Mapping for Regional Water Resources Studies," *Use of Computers in Water Management*, Vol. 1, pp. 216-228, V/O "Syuzvodproekt", Moscow, USSR, 1989. (Also in Russian: Vol. 2, pp. 234-249.)
9. Geiselbrecht, A., S. Rouhani, K. Thorbjornsen, D. Blue, "Scientific Methods for Determining Anthropogenic Background." *Battellle Tenth International Conference on Remediation and Management of Contaminated Sediments.* February 13, 2019.

EXHIBIT 1

PROFESSIONAL ACTIVITIES

1. American Geophysical Union:
   Member, 1981-Present.
   Associate Editor, *Water Resources Research*, 1989-1994.
2. American Society of Civil Engineering:
   Associate Member, 1983-1987.
   Member, 1987.
   Chairman, National Ground Water Hydrology Committee (Standing Committee), Hydraulics Division, Oct. 1991-1992.
   Chairman, ASCE Task Committee on Geostatistical Techniques in Geohydrology, Ground Water Hydrology Technical Committee, American Society of Civil Engineers, Hydraulics Division, Oct. 1987-Sept. 1989.
   Contact Member, ASCE Task Committee on Groundwater Monitoring Network Design, Probabilistic Approaches to Hydraulics and Hydrology Committee, Hydraulic Division, Oct. 1988- Sept. 1990.
   Secretary, ASCE Water Resources Committee, American Society of Civil Engineers, Georgia Section, 1988.
   Special Session Organizer, Special Session on "Development and Applications of Geostatistics in Geohydrology," 1989 ASCE National Conference on Hydraulic Engineering, New Orleans, August 14-18, 1989.
   Special Session Organizer and Chairman, Special Session on Geostatistics in Geohydrology, 1990 ASCE Water Resources Conference, Fort Worth, April, 1990.
   Symposium Organizer, International Symposium on Ground Water, 1991 ASCE National Conference on Hydraulic Engineering, Nashville, July, 1991.
3. International Water Resources Association: Member, 1985.
4. American Water Resources Association: Member, 1986.
5. North American Council on Geostatistics, 1987.
6. International Geostatistical Association: Member, 1989.
7. Association for Environmental Health and Sciences (AEHS):
   Member, 2003.
   Member of Editorial Board, *Environmental Forensics*, 2003-Present.

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ATTACHMENT A – MCVEHIL V. SULLIVAN-MCVEHIL

Lead

Table A-1. Station-specific Monthly Lead Predicted by Dr. McVehil (MMA 2008b) vs. Predicted by Sullivan-McVehil.

Station	Month Year	McVehil	Sullivan-McVehil	% Difference*
Sindicato	March 2007	1.74	1.69	-3%
	April 2007	1.21	2.50	+107%
	May 2007	0.85	2.29	+170%
	June 2007	0.75	2.50	+233%
	July 2007	0.77	1.21	+57%
	August 2007	0.77	1.48	+92%
	September 2007	0.87	1.36	+56%
	October 2007	1.55	4.54	+193%
	November 2007	1.27	7.30	+475%
	December 2007	1.68	NA	-
	January 2008	1.93	2.62	+36%
	February 2008	1.63	4.02	+147%
Marcavalle	March 2007	0.62	0.19	-69%
	April 2007	0.53	0.20	-62%
	May 2007	0.42	0.09	-79%
	June 2007	0.42	0.09	-80%
	July 2007	0.38	0.05	-86%
	August 2007	0.46	0.07	-84%
	September 2007	0.56	0.05	-91%
	October 2007	0.56	0.13	-76%
	November 2007	0.57	0.16	-71%
	December 2007	0.58	NA	-
	January 2008	0.8	0.20	-75%
	February 2008	0.8	0.13	-83%
Huanchan	March 2007	8.05	0.77	-90%
	April 2007	8.68	0.71	-92%
	May 2007	6.43	0.89	-86%
	June 2007	7.45	1.17	-84%
	July 2007	6.81	0.64	-91%
	August 2007	7.01	1.07	-85%
	September 2007	5.67	0.86	-85%
	October 2007	5.27	0.28	-95%
	November 2007	4.47	0.45	-90%
	December 2007	3.02	NA	-
	January 2008	2.61	1.06	-59%
	February 2008	2.75	0.97	-65%

EXHIBIT 1

Station	Month Year	McVehil	Sullivan-McVehil	% Difference*
Hotel Inca	March 2007	1.06	0.55	-48%
	April 2007	0.93	0.28	-70%
	May 2007	0.65	0.29	-55%
	June 2007	0.62	0.42	-33%
	July 2007	0.62	0.08	-87%
	August 2007	0.64	0.53	-17%
	September 2007	0.7	0.23	-68%
	October 2007	0.89	0.49	-45%
	November 2007	0.89	0.79	-11%
	December 2007	1.03	NA	-
	January 2008	1.18	0.61	-49%
	February 2008	1.09	0.55	-50%

*(McVehil – Sullivan- McVehil)/Sullivan- McVehil

SO_2

Table A-2. Annual SO_2 Predicted by Dr. McVehil (MMA 2008a) vs. Predicted by Sullivan-McVehil.

Station	Statistic	McVehil[1]	Sullivan - McVehil[2]	% Difference[3]
Hotel Inca	Annual Average SO_2 ($\mu g/m^3$)	403	190	-53%
Sindicato		744	737	-1%
Huanchan		2104	314	-85%
Marcavalle		378	82	-78%
Hotel Inca	Annual 24-Hour Max SO2 ($\mu g/m^3$)	2283	853	-63%
Sindicato		5981	3282	-45%
Huanchan		6676	1140	-83%
Marcavalle		1943	373	-81%

1) Source: MMA (2008b) (Ref 113, Table 6.1, p. 30) & MMA (2008b) (Ref 113, Table 6-2, pdf p. 58)
2) Source: "MC-VEHILL-NO-BUILDING\MODEL-PERFORMANCE-ADJ-HEIGHT(2.5H)-(SO2).xlsx"
3) % Difference = (Sullivan-McVehil – McVehil)/McVehil

Table A-3. Station-specific Monthly Average SO_2 Predicted by Dr. McVehil (MMA 2008b) vs. Predicted by Sullivan-McVehil.

Station	Month Year	McVehil	Sullivan-McVehil	% Difference*
Sindicato	March 2007	1186	NA	-
	April 2007	556	723	+30%
	May 2007	286	578	+102%
	June 2007	185	688	+272%
	July 2007	219	315	+44%
	August 2007	249	522	+110%
	September 2007	312	347	+11%
	October 2007	1061	1076	+1%
	November 2007	736	1270	+73%
	December 2007	1268	1332	+5%
	January 2008	1594	682	-57%
	February 2008	1283	565	-56%
Marcavalle	March 2007	461	110	-76%
	April 2007	358	112	-69%
	May 2007	231	49	-79%
	June 2007	214	60	-72%
	July 2007	197	47	-76%
	August 2007	246	45	-82%
	September 2007	345	39	-89%
	October 2007	384	94	-75%
	November 2007	376	114	-70%
	December 2007	387	101	-74%
	January 2008	635	98	-85%
	February 2008	704	134	-81%
Huanchan	March 2007	2553	325	-87%
	April 2007	2831	317	-89%
	May 2007	2615	374	-86%
	June 2007	2765	406	-85%
	July 2007	2445	293	-88%
	August 2007	2482	366	-85%
	September 2007	2172	290	-87%
	October 2007	1850	211	-89%
	November 2007	1742	245	-86%
	December 2007	1228	320	-74%
	January 2008	1197	290	-76%
	February 2008	1365	331	-76%
Hotel Inca	March 2007	572	219	-62%

EXHIBIT 1

Station	Month Year	McVehil	Sullivan-McVehil	% Difference*
	April 2007	391	199	-49%
	May 2007	212	101	-52%
	June 2007	184	182	-1%
	July 2007	166	75	-55%
	August 2007	163	133	-19%
	September 2007	227	107	-53%
	October 2007	456	203	-55%
	November 2007	418	275	-34%
	December 2007	568	213	-63%
	January 2008	793	324	-59%
	February 2008	687	255	-63%

*(McVehil – Sullivan- McVehil)/Sullivan- McVehil

EXHIBIT 1

ATTACHMENT B – NONCONCURRENT RELIABILITY ANALYSES

Nonconcurrent Lead

Table B-1. Station-specific Comparison of Measured Three-month Annual Maximum Lead vs. Predicted Values for Sullivan Modeling Scenarios. Highlighted Cells are ± 40% Different than Measured Values.

Station	Measured	Sullivan-Cheremisinoff		Sullivan-McVehil		Sullivan-Sullivan	
		Predicted	% Difference*	Predicted	% Difference*	Predicted	% Difference*
INCA	1.27	1.02	-20%	0.64	-50%	1.23	-4%
HUAN	6.47	1.92	-70%	0.96	-85%	2.44	-62%
CASA	0.42	0.08	-82%	0.08	-82%	0.13	-69%
MARC	1.03	0.21	-79%	0.17	-83%	0.37	-64%
HUAR	0.77	0.08	-90%	0.08	-90%	0.18	-76%
SIND	2.09	5.08	144%	5.92	184%	4.48	115%
HUAY	0.45	0.10	-77%	0.10	-77%	0.18	-59%

*(Modeled – Measured)/Modeled

Nonconcurrent Arsenic

Table B-2. Station-specific Comparison of Measured Annual Average Arsenic vs. Predicted Values for Sullivan Modeling Scenarios. Highlighted Cells are ± 40% Different than Measured Values.

Station	Measured	Sullivan-Cheremisinoff		Sullivan-McVehil		Sullivan-Sullivan	
		Predicted	% Difference*	Predicted	% Difference*	Predicted	% Difference*
INCA	0.83	0.78	-6%	New run of Sullivan-McVehil for arsenic has not been provided by Mr. Sullivan.		0.49	-41%
HUAN	4.01	2.30	-43%			0.67	-83%
CASA	0.17	0.04	-76%			0.05	-71%
MARC	0.42	0.14	-67%			0.14	-67%
HUAR	0.39	0.05	-87%			0.08	-79%
SIND	1.01	3.63	259%			1.42	41%
HUAY	0.18	0.05	-72%			0.07	-61%

*(Modeled – Measured)/Modeled

EXHIBIT 1

Nonconcurrent SO_2

Table B-3. Station-specific Comparison of Measured 99th Percentile Daily Max SO_2 vs Predicted Values for Sullivan Modeling Scenarios.
Highlighted Cells are ± 40% Different than Measured Values.

Station	Measured	Sullivan-Cheremisinoff		Sullivan-McVehil		Sullivan-Sullivan	
		Predicted	% Difference*	Predicted	% Difference*	Predicted	% Difference*
INCA	11552	9295	-20%	6980	-40%	9295	-20%
CUSH	3153	1872	-41%	1804	-43%	1871	-41%
HUAN	27246	8810	-68%	7939	-71%	8810	-68%
CASA	1577	803	-49%	787	-50%	764	-52%
MARC	5184	2651	-49%	2476	-52%	2651	-49%
HUAR	5513	1107	-80%	1120	-80%	1109	-80%
SIND	16539	18167	10%	17327	5%	18167	10%
HUAY	1926	1238	-36%	1264	-34%	1274	-34%

*(Modeled – Measured)/Modeled

ATTACHMENT C – CONCURRENT RELIABILITY ANALYSES

Concurrent Lead

Figure C-1. Measured vs. Predicted Sullivan-Cheremisinoff 2007 Daily Lead

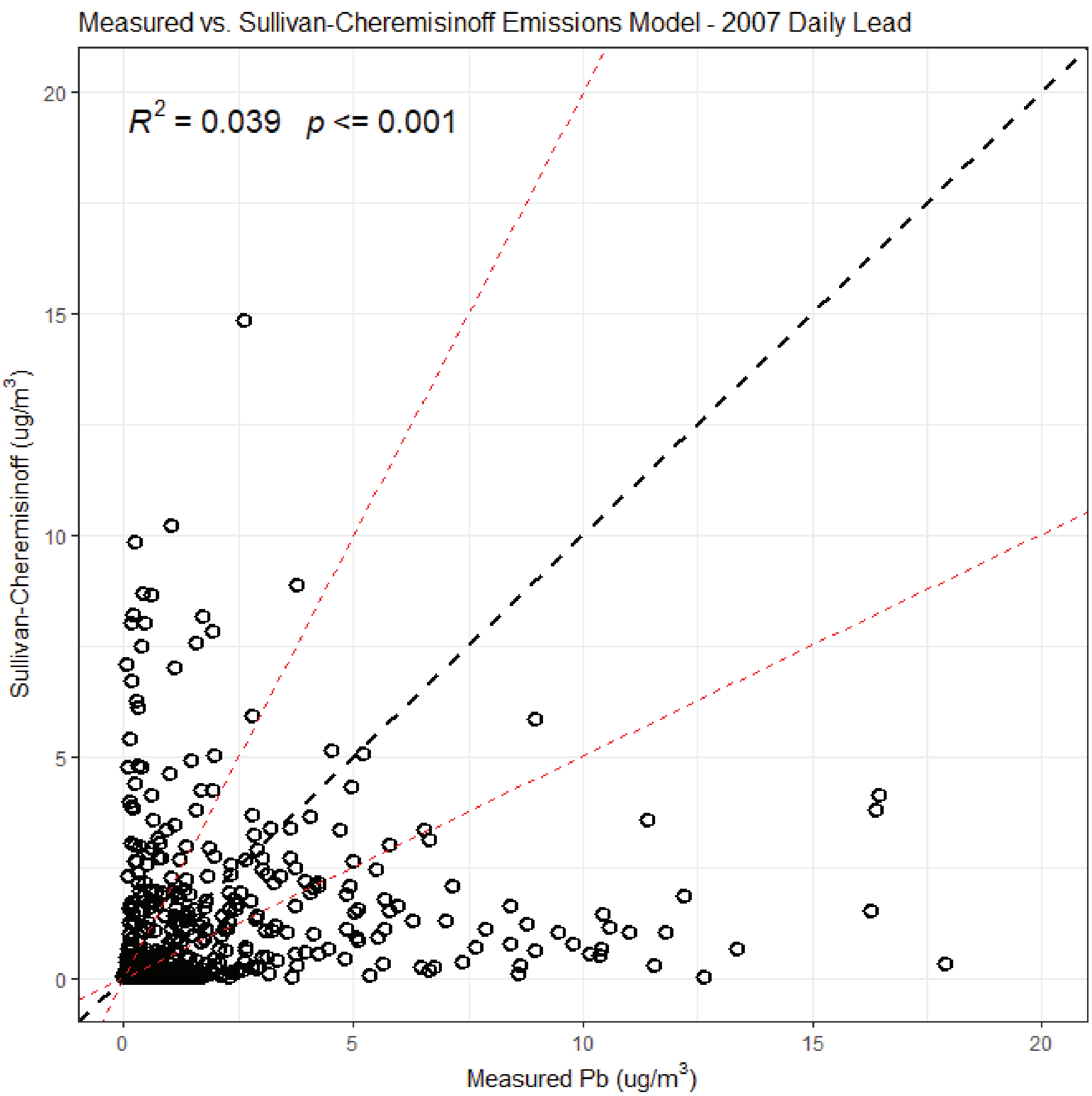

EXHIBIT 1

Figure C-2. Station-specific Measured vs. Predicted Sullivan-Cheremisinoff 2007 Daily Lead

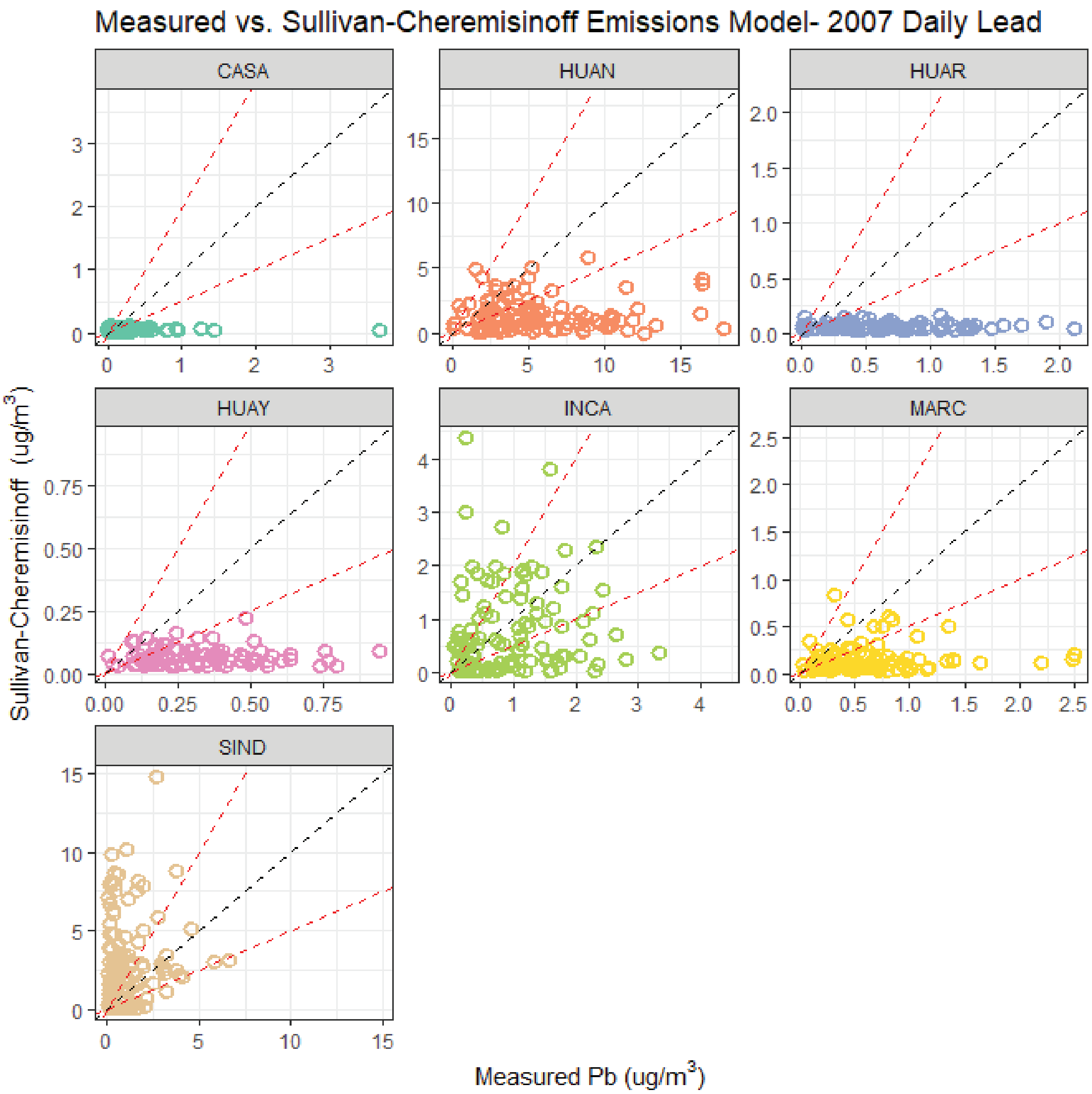

EXHIBIT 1

Figure C-3. Measured vs. Predicted Sullivan-Sullivan 2007 Daily Lead

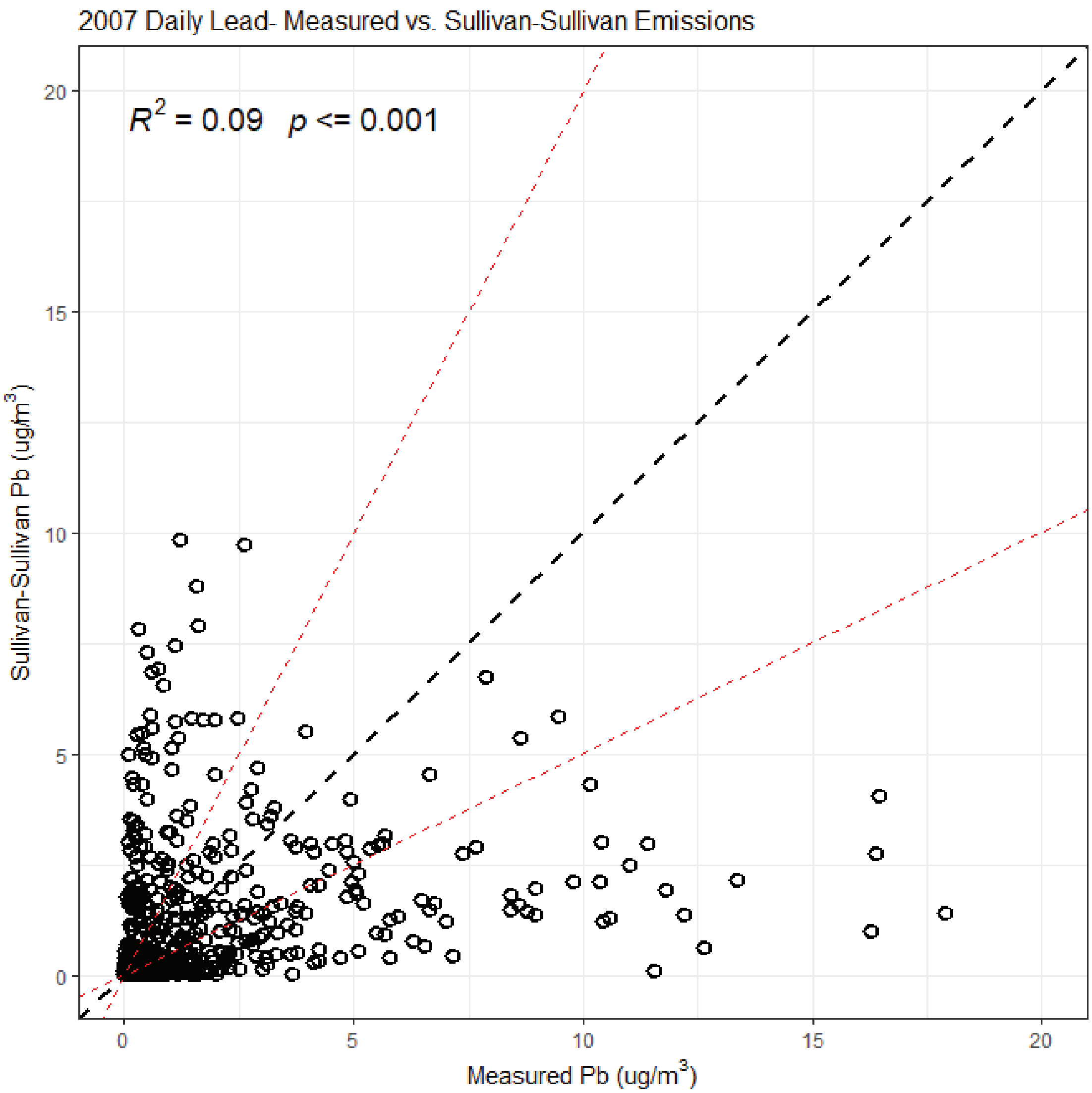

EXHIBIT 1

Figure C-4. Station-specific Measured vs. Predicted Sullivan-Sullivan 2007 Daily Lead

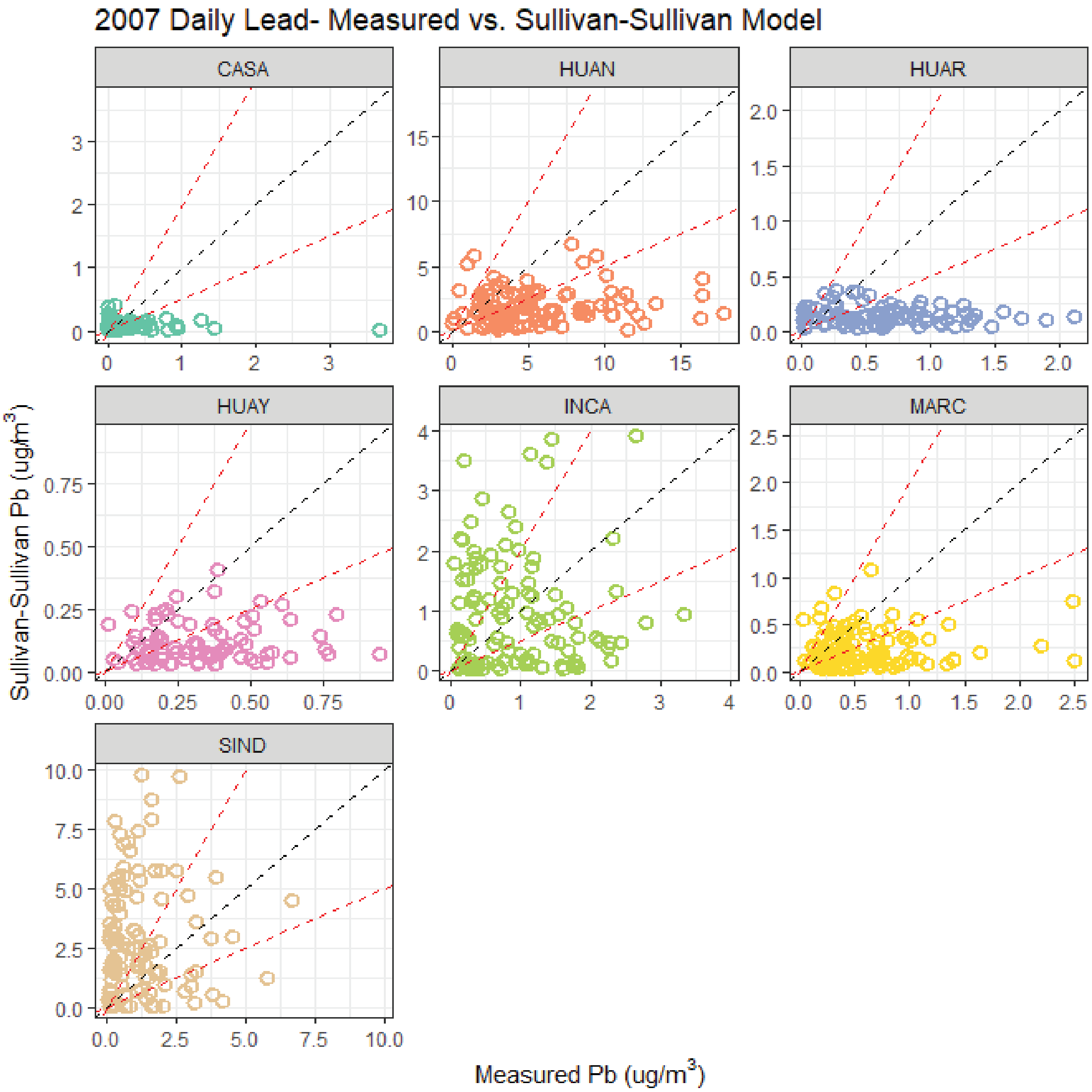

EXHIBIT 1

Figure C-5. Measured vs. Predicted Sullivan-McVehil 2007 Daily Lead

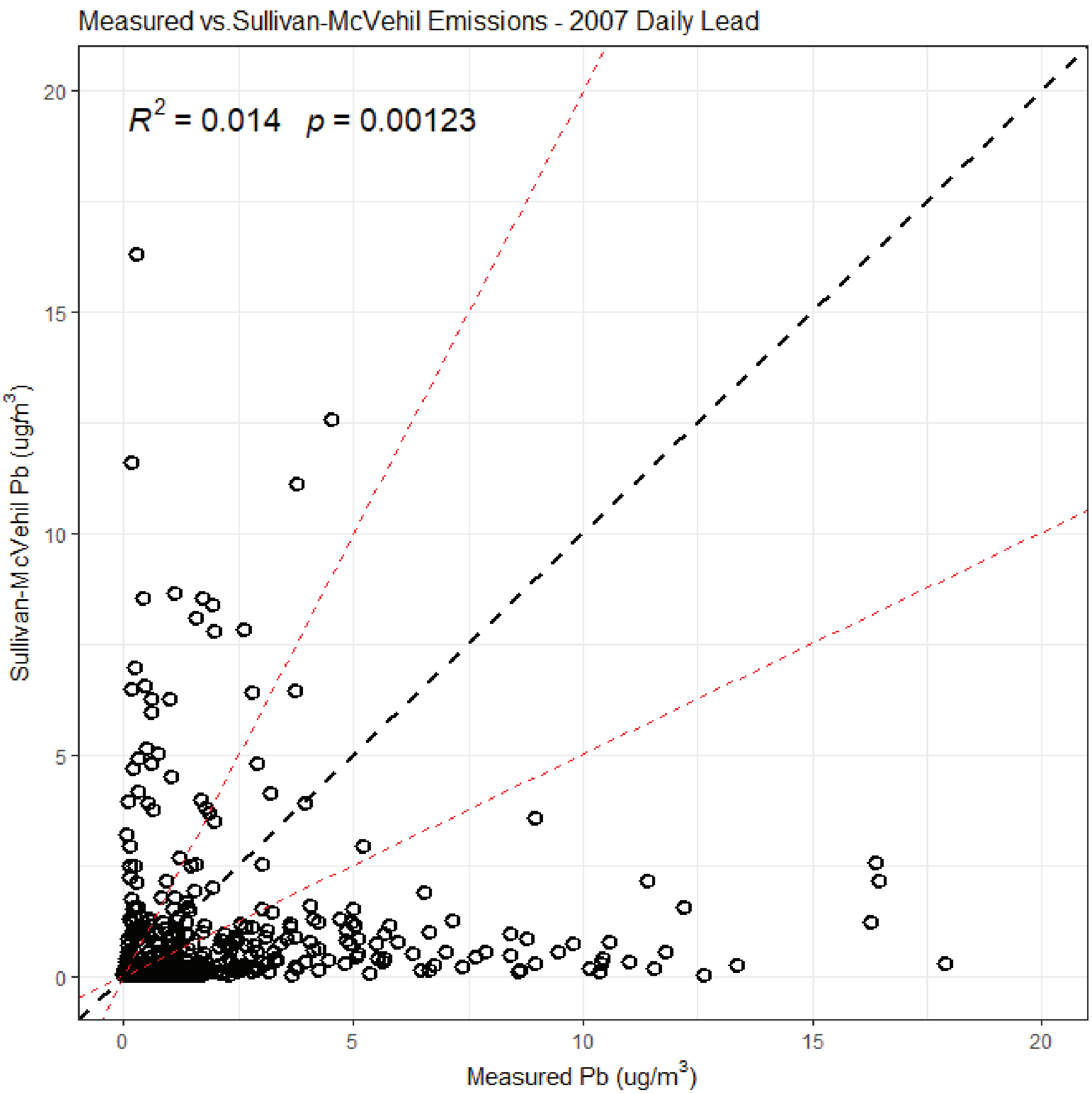

EXHIBIT 1

Figure C-6. Station-specific Measured vs. Predicted Sullivan-McVehil 2007 Daily Lead

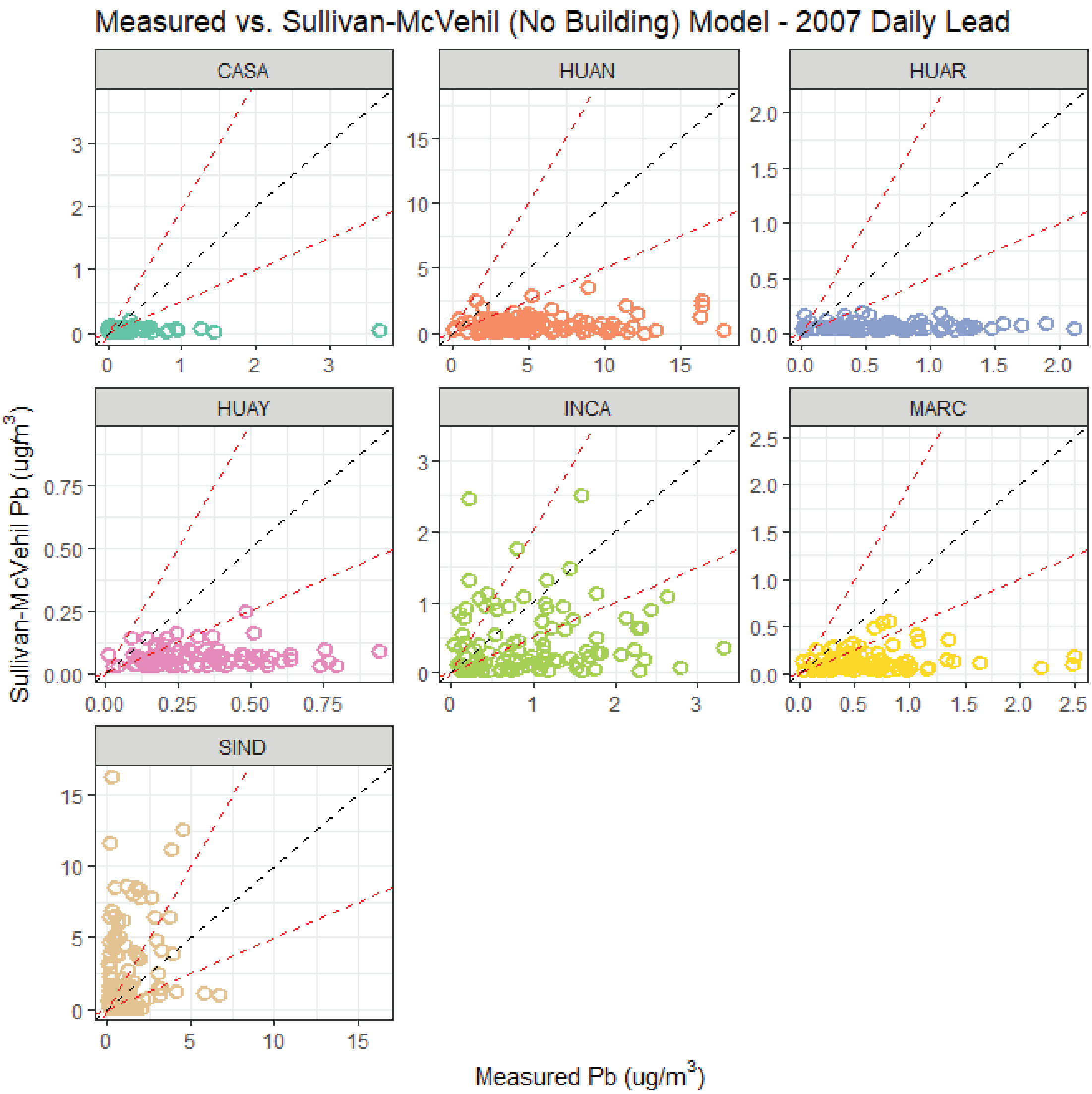

EXHIBIT 1

Concurrent Arsenic

Figure C-7. Measured vs. Predicted Sullivan-Cheremisinoff 2007 Daily Arsenic

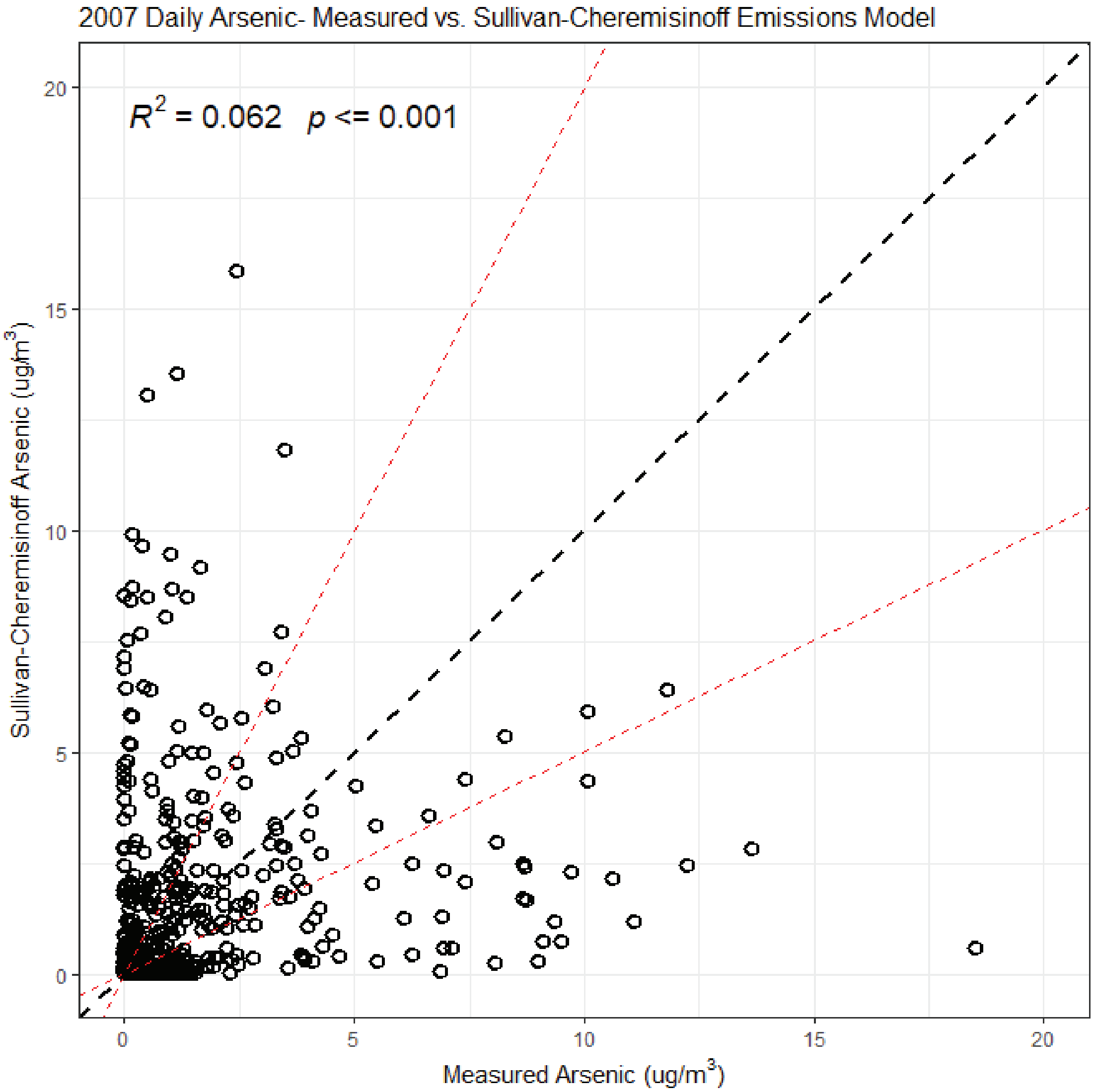

EXHIBIT 1

Figure C-8. Station-specific Measured vs. Predicted Sullivan-Cheremisinoff 2007 Daily Arsenic

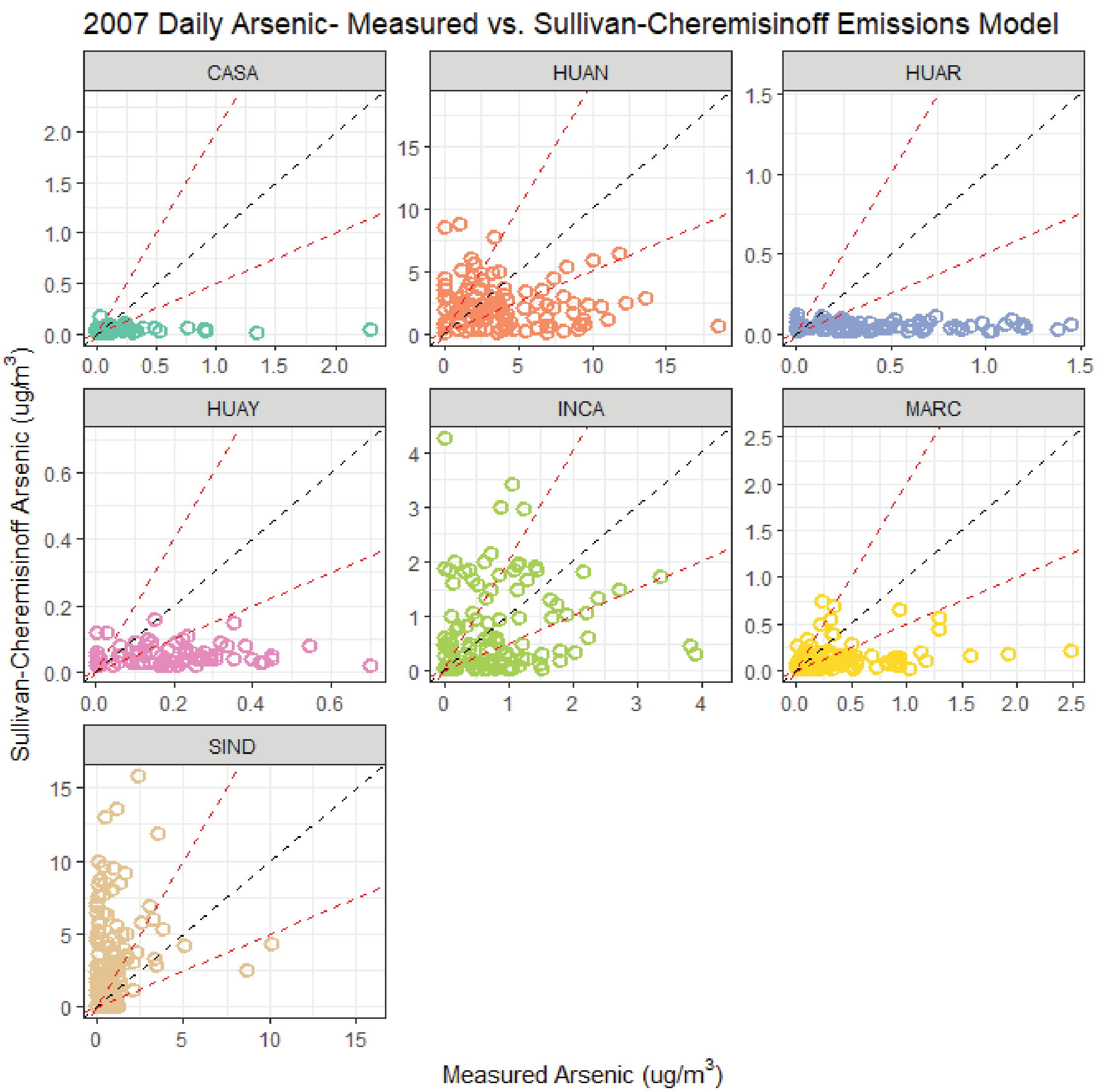

EXHIBIT 1

Figure C-9. Measured vs. Predicted Sullivan-Sullivan 2007 Daily Arsenic

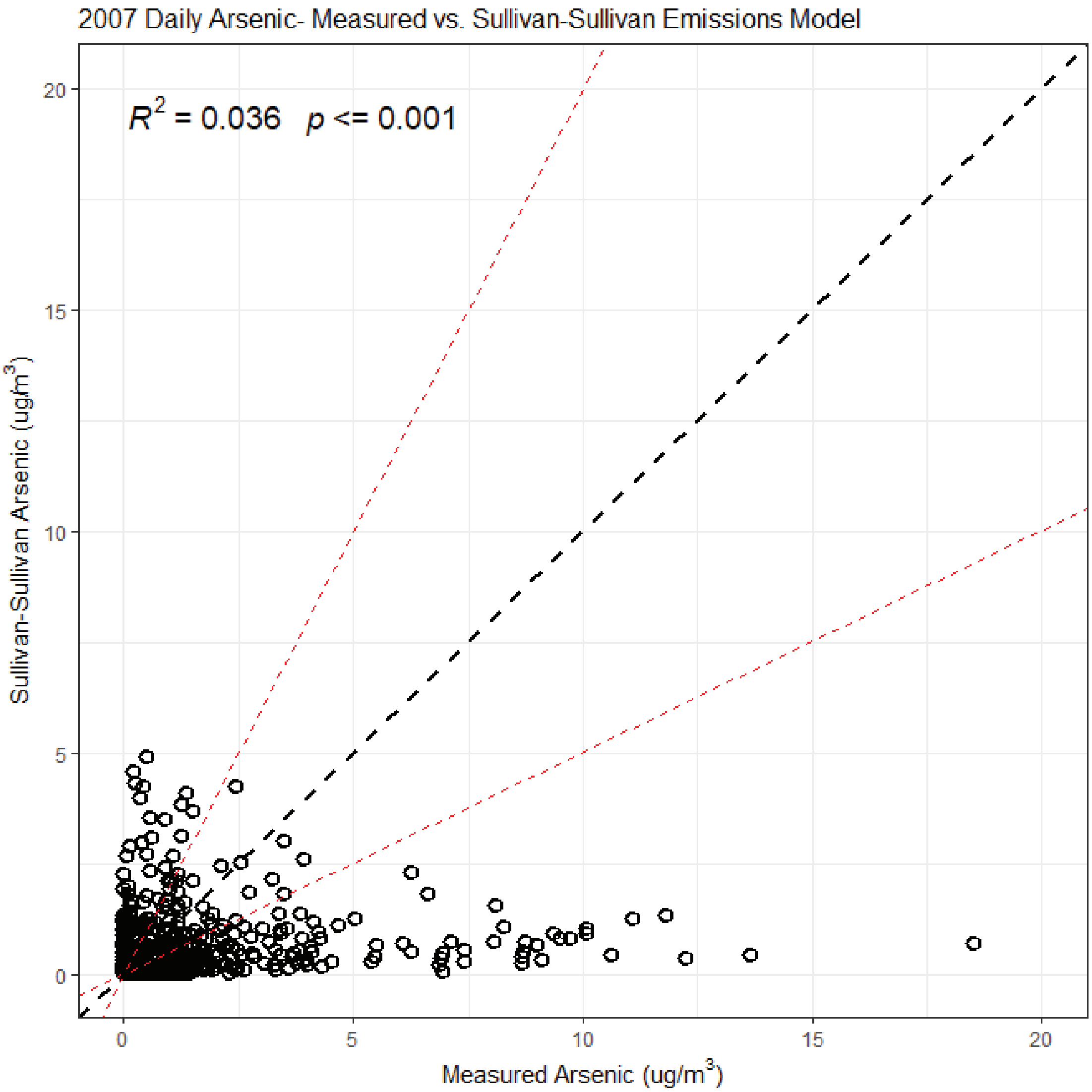

EXHIBIT 1

Figure C-10. Station-specific Measured vs. Predicted Sullivan-Sullivan 2007 Daily Arsenic

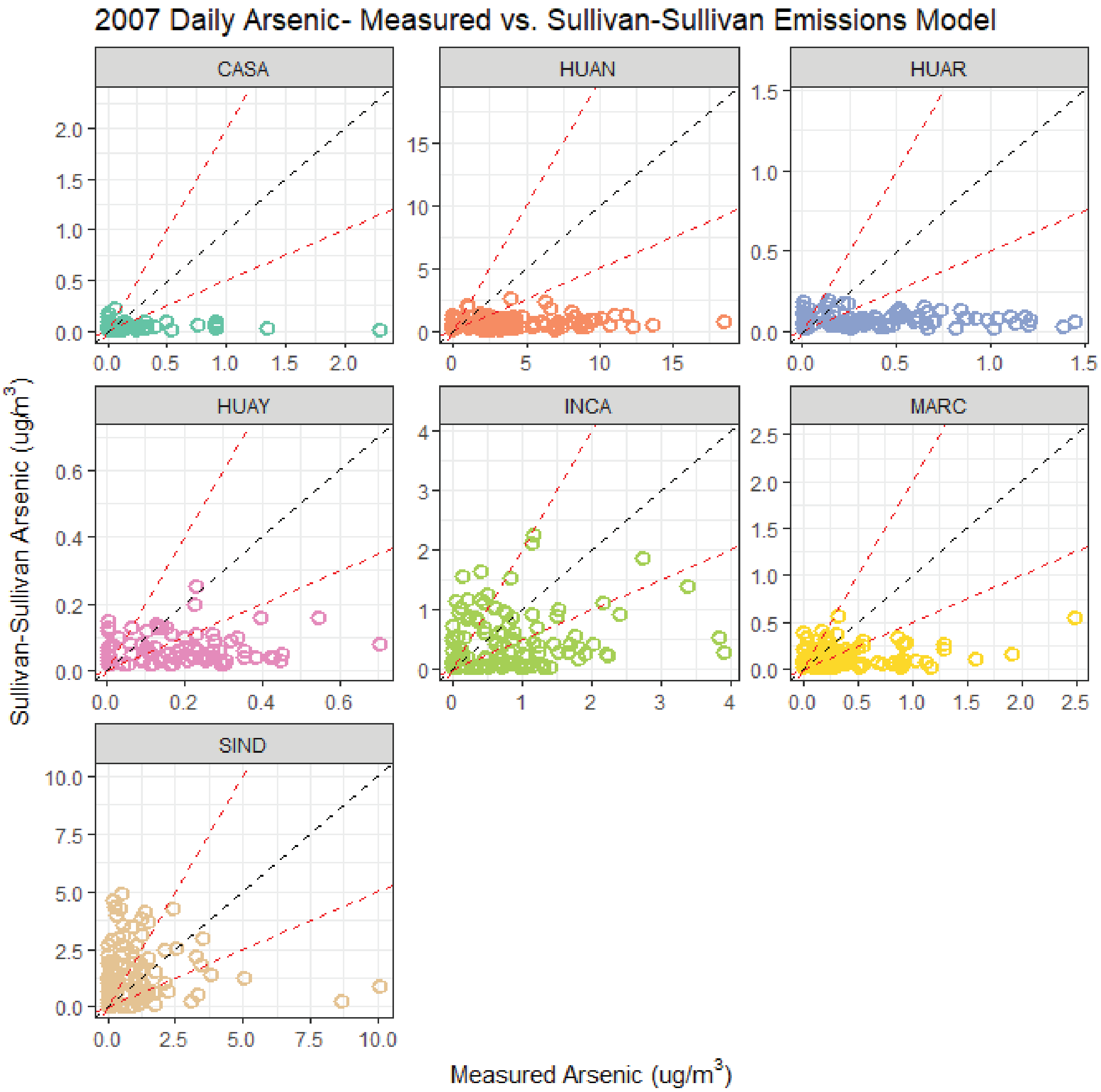

Figure C-11. Measured vs. Predicted Sullivan-McVehil 2007 Daily Arsenic

New run of Sullivan-McVehil for arsenic has not been provided by Mr. Sullivan.

Figure C-12. Station-specific Measured vs. Predicted Sullivan-McVehil 2007 Daily Arsenic

New run of Sullivan-McVehil for arsenic has not been provided by Mr. Sullivan.

EXHIBIT 1

Concurrent SO_2

Figure C-13. Measured vs. Predicted Sullivan-Cheremisinoff 2007 Hourly SO_2

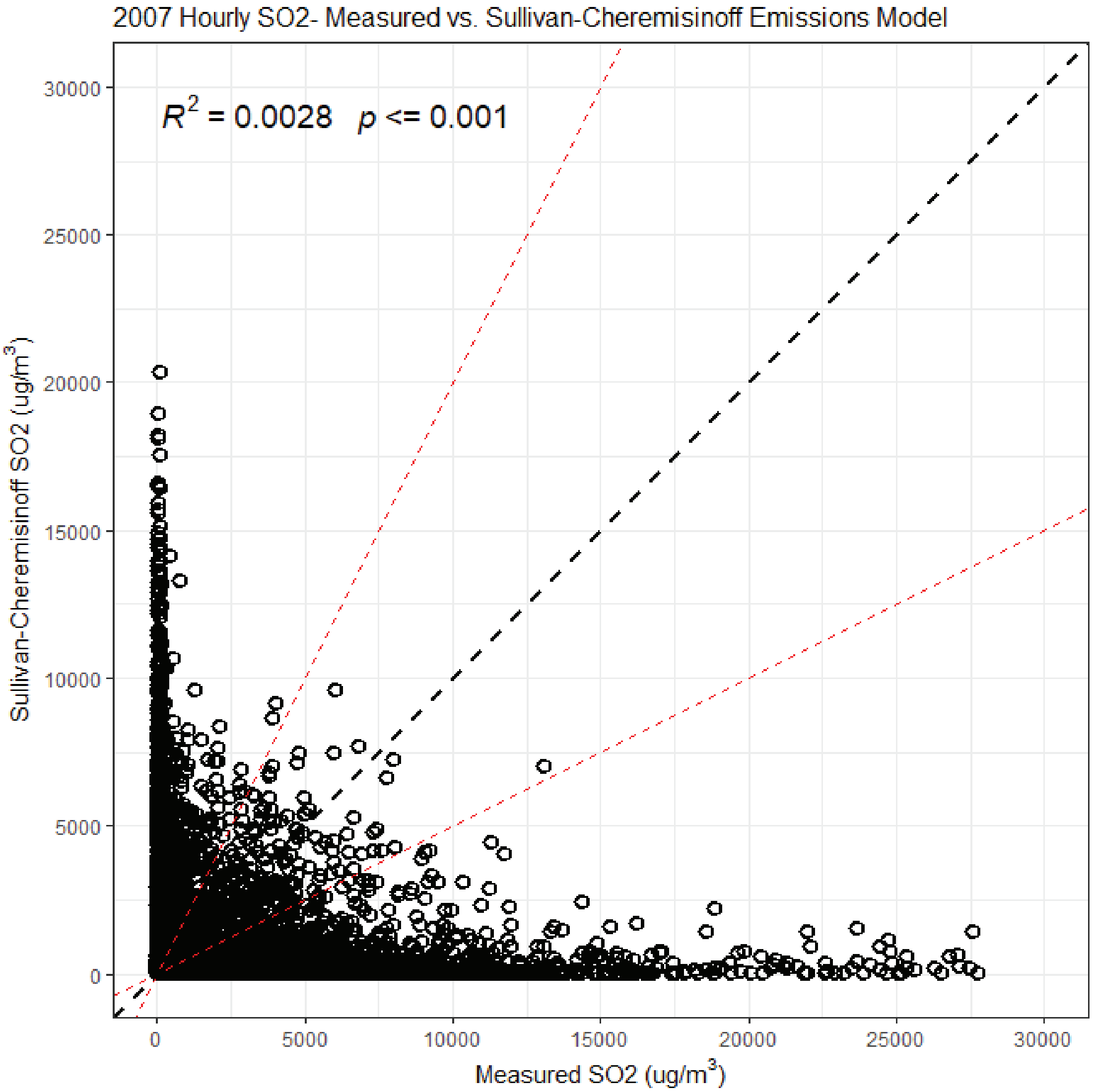

EXHIBIT 1

Figure C-14. Station-specific Measured vs. Predicted Sullivan-Cheremisinoff 2007 Hourly SO_2

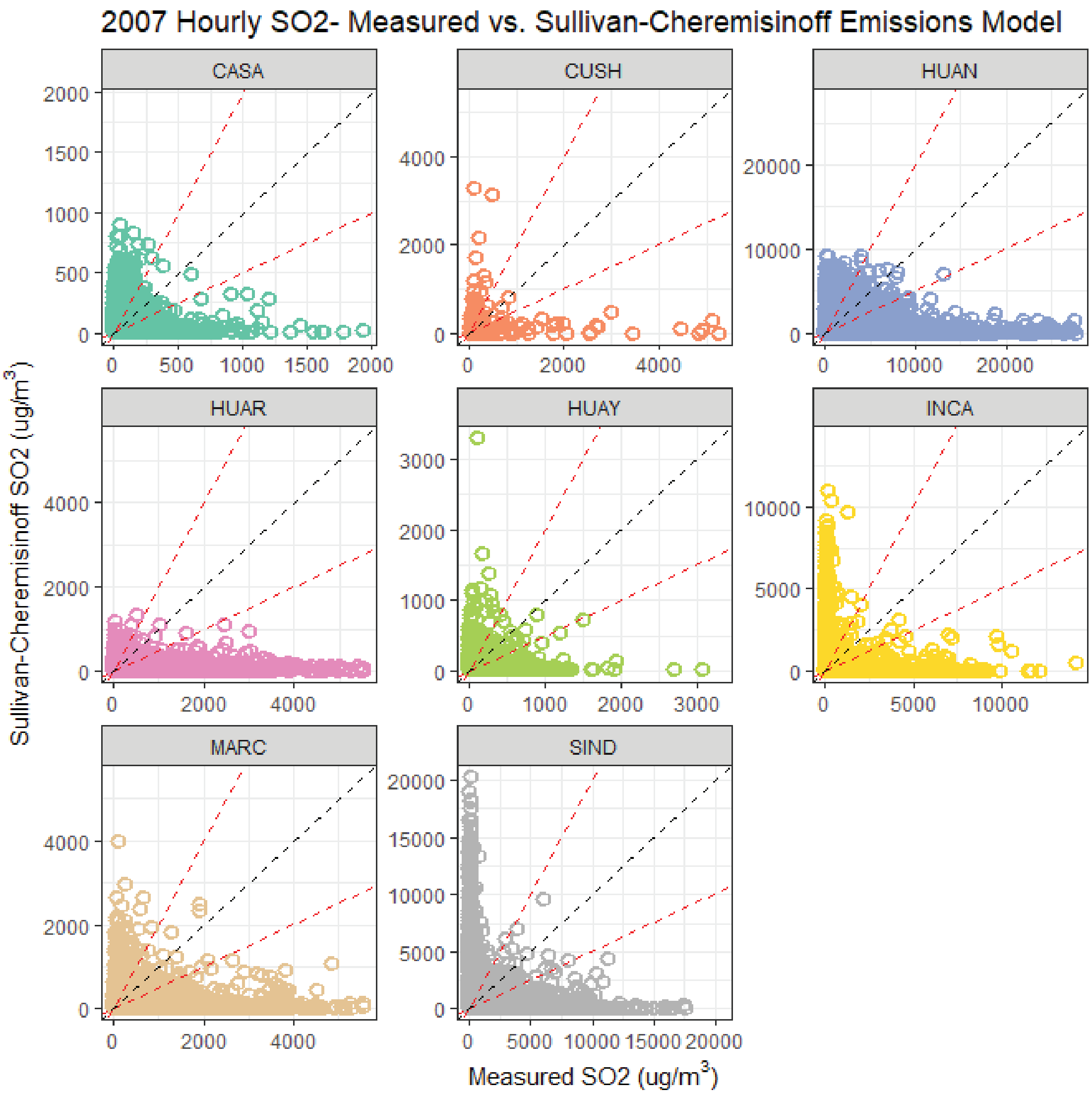

EXHIBIT 1

Figure C-15. Measured vs. Predicted Sullivan-Sullivan 2007 Hourly SO_2

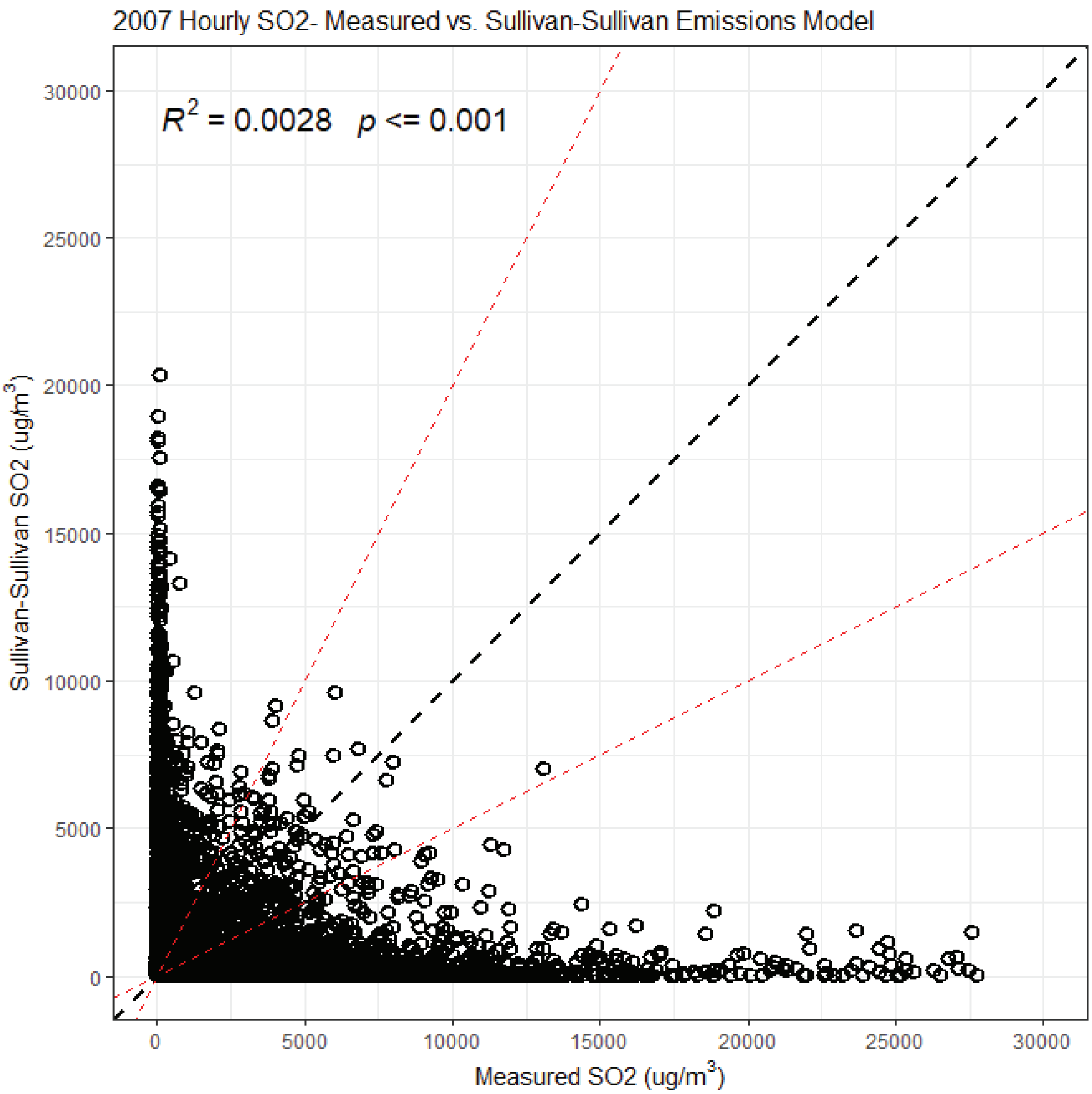

EXHIBIT 1

Figure C-16. Station-specific Measured vs. Predicted Sullivan-Sullivan 2007 Hourly SO_2

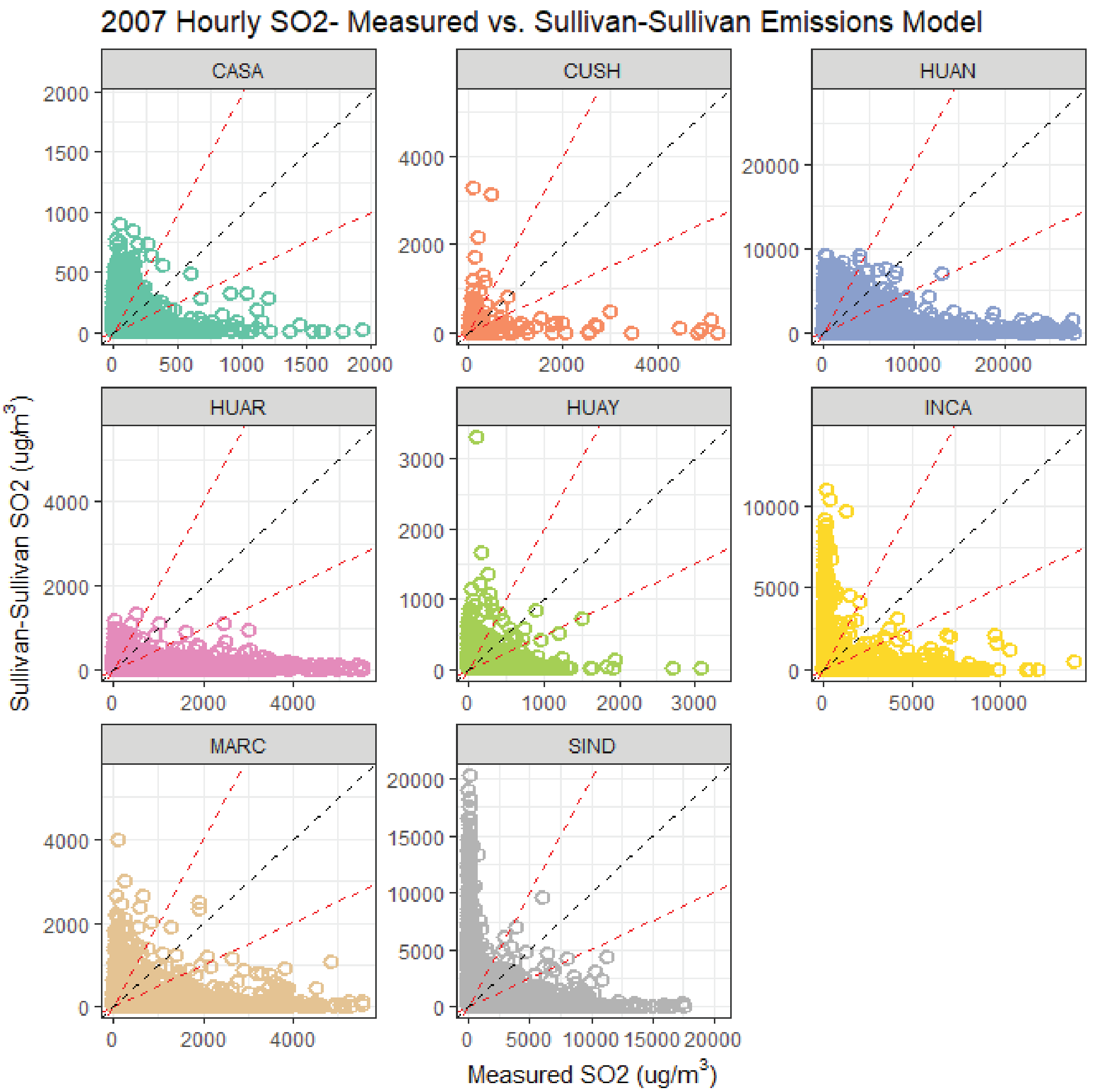

EXHIBIT 1

Figure C-17. Measured vs. Predicted Sullivan-McVehil 2007 Hourly SO_2

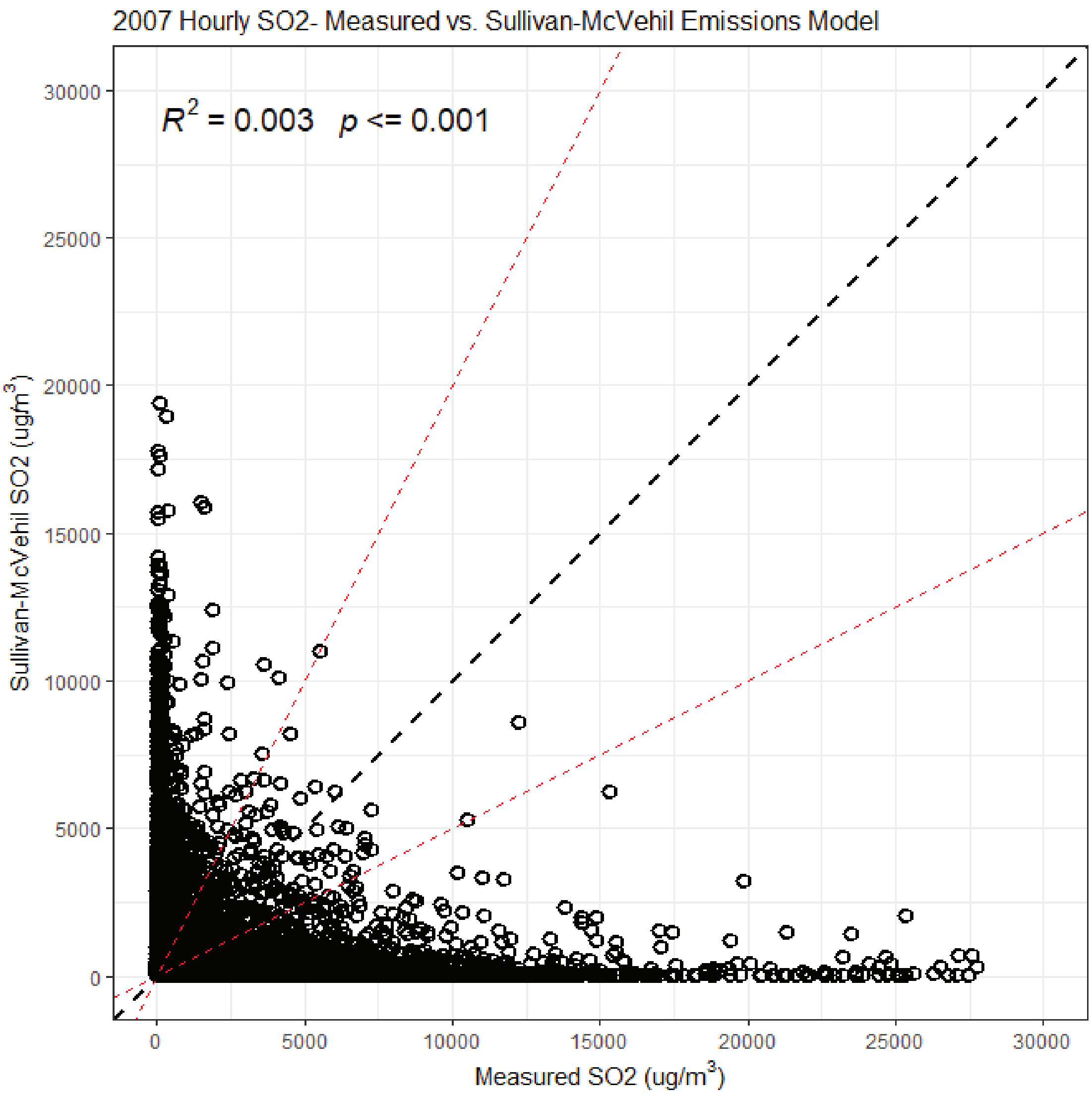

EXHIBIT 1

Figure C-18. Station-specific Measured vs. Predicted Sullivan-McVehil 2007 Hourly SO_2

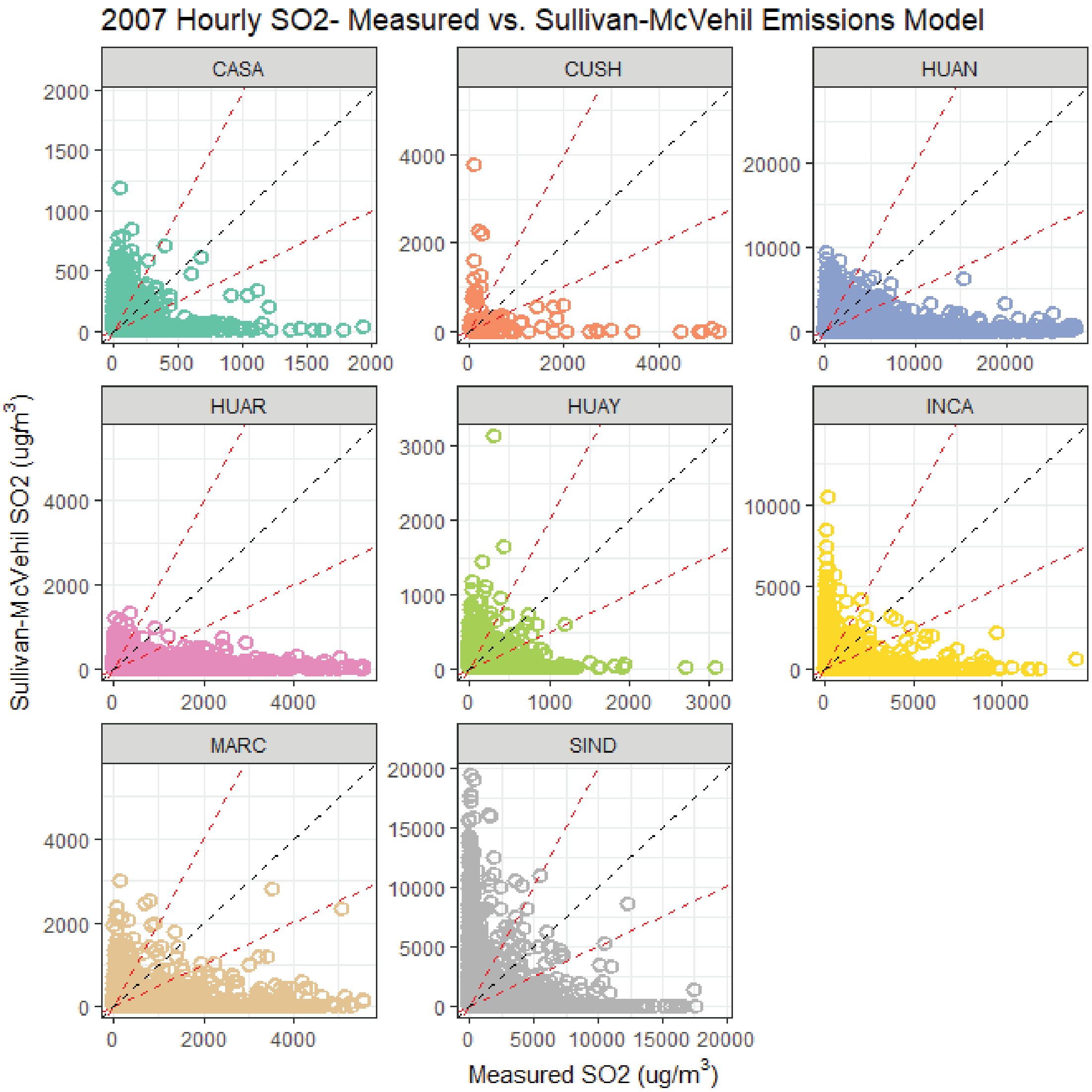

EXHIBIT 1

ATTACHMENT D – CONCURRENT CONSISTENCY

Concurrent Lead

Table D-1. Comparison of 2007 Daily Lead Predictions based on Sullivan-Sullivan versus Sullivan-Cheremisinoff Model Runs

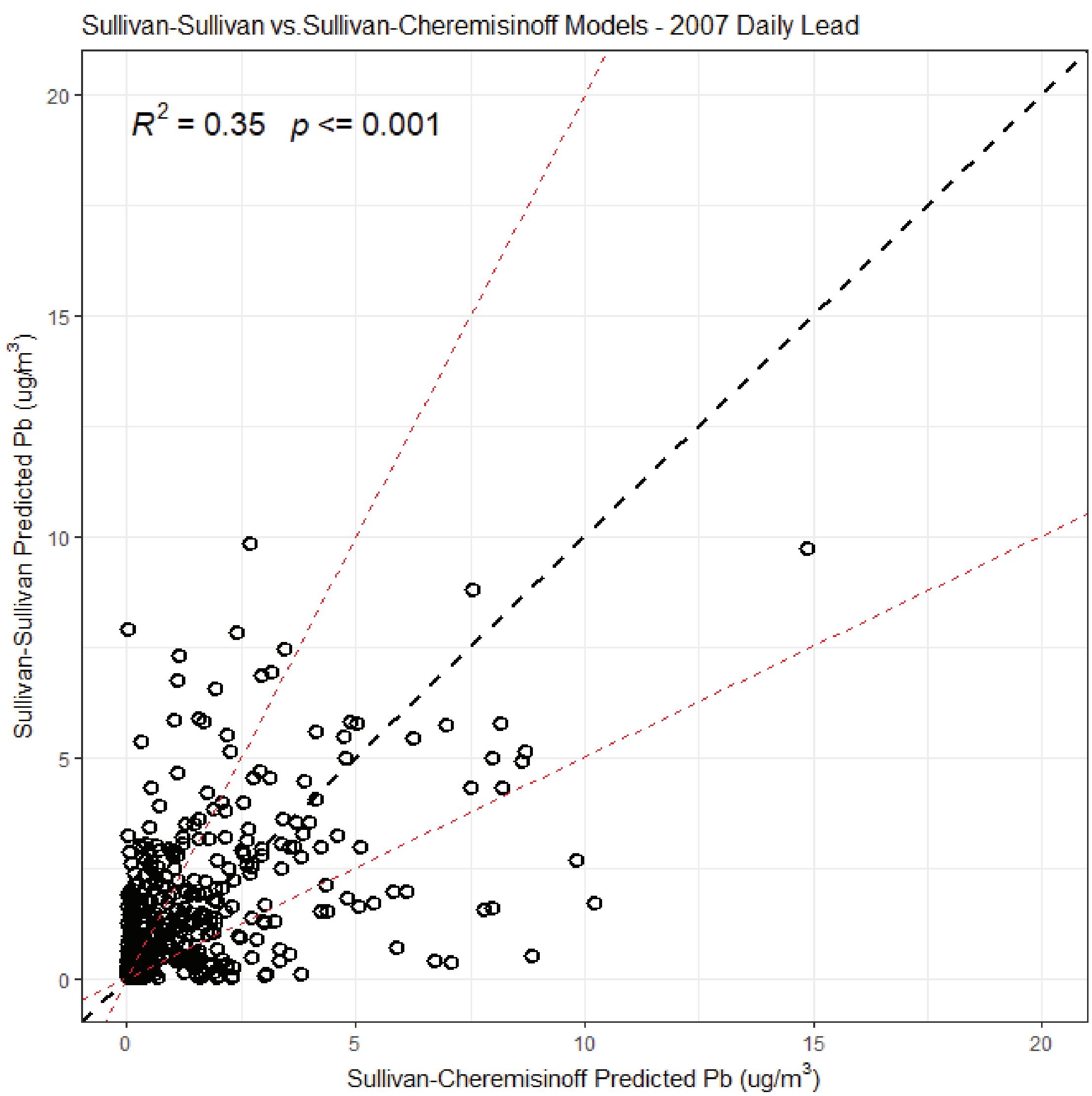

EXHIBIT 1

Table D-2. Station-specific Comparison of 2007 Daily Lead Predictions based on Sullivan-Sullivan versus Sullivan-Cheremisinoff Model Runs

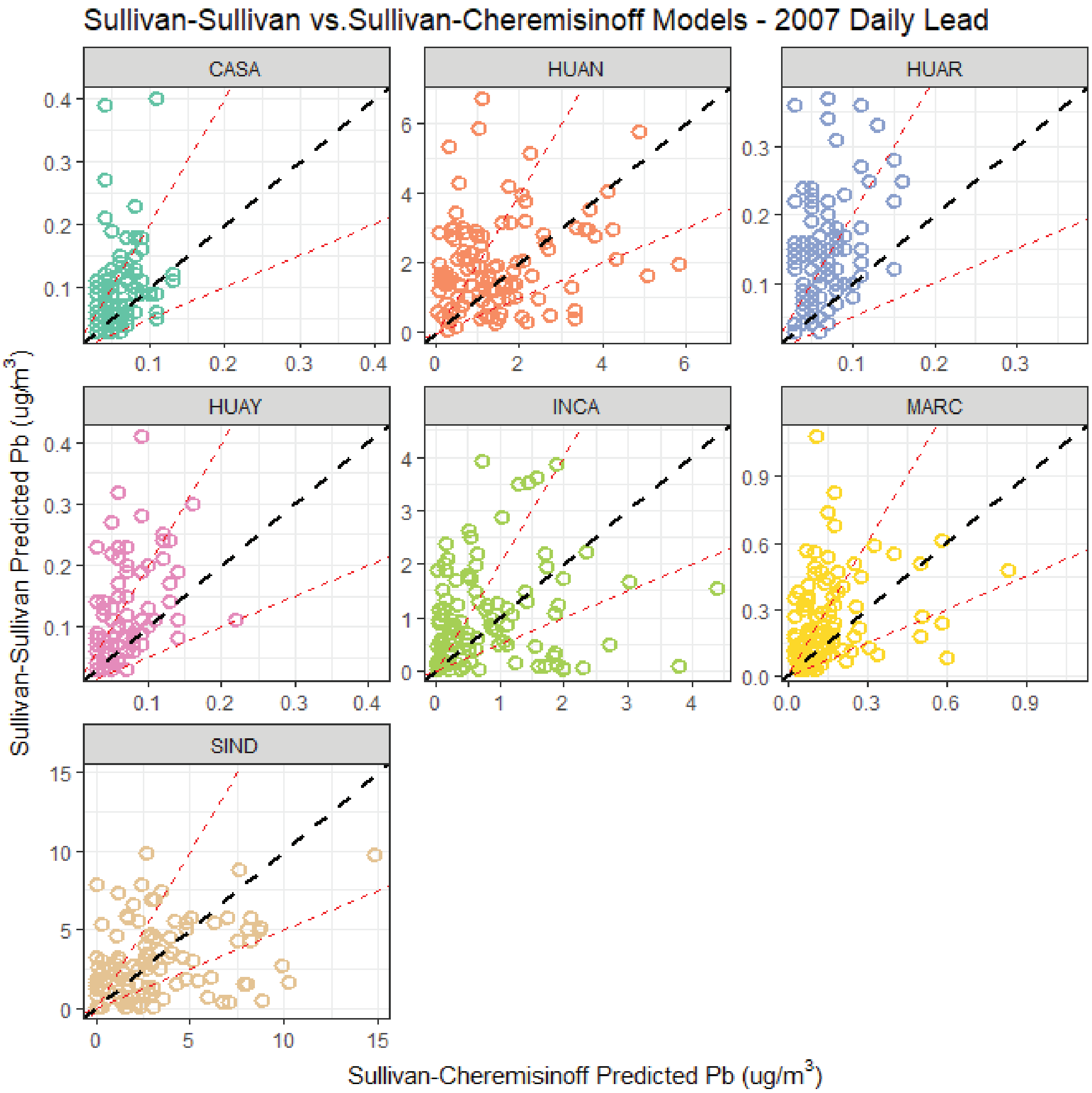

EXHIBIT 1

Table D-3. Comparison of 2007 Daily Lead Predictions based on Sullivan-Sullivan versus Sullivan-McVehil Model Runs

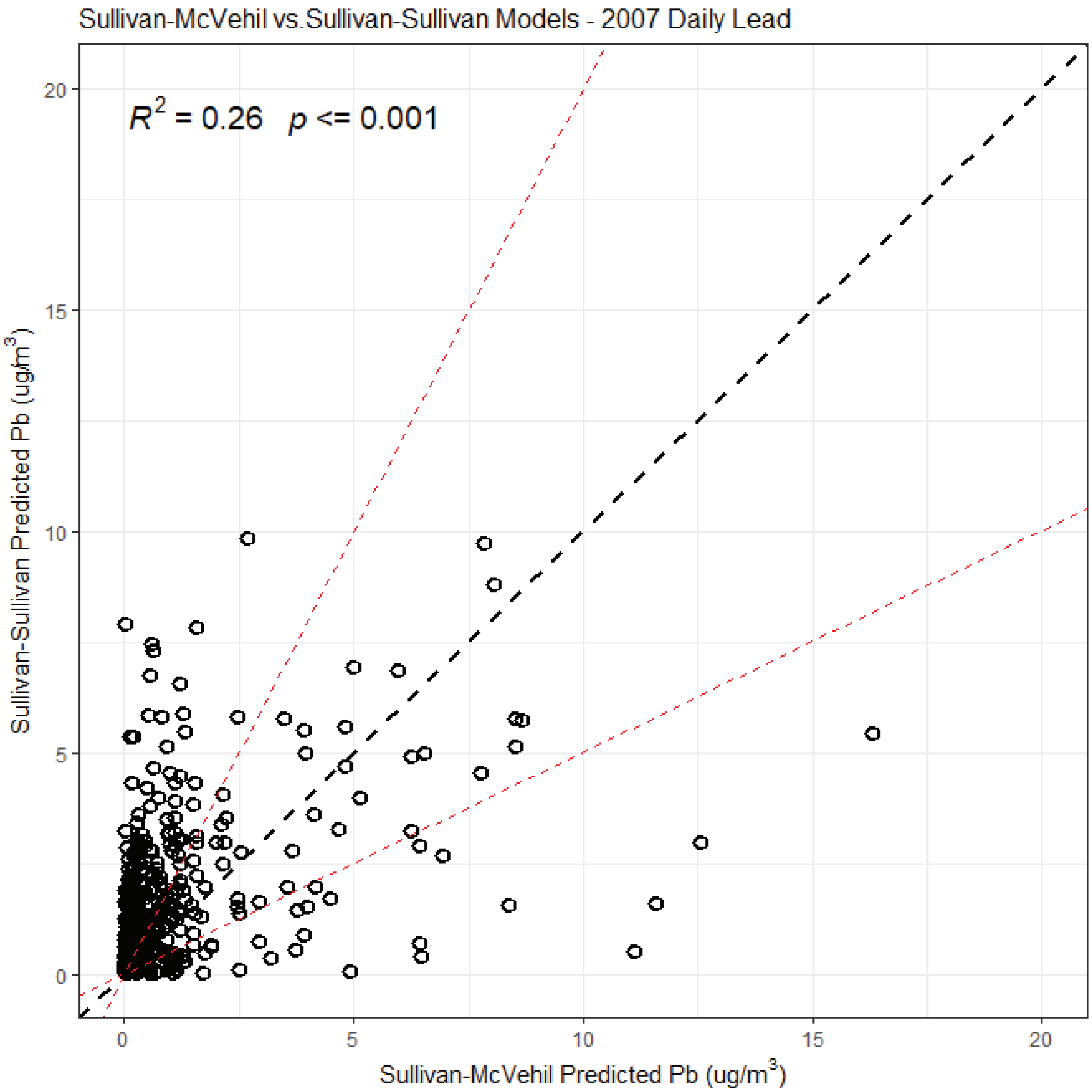

EXHIBIT 1

Table D-4. Station-specific Comparison of 2007 Daily Lead Predictions based on Sullivan-Sullivan versus Sullivan-McVehil Model Runs

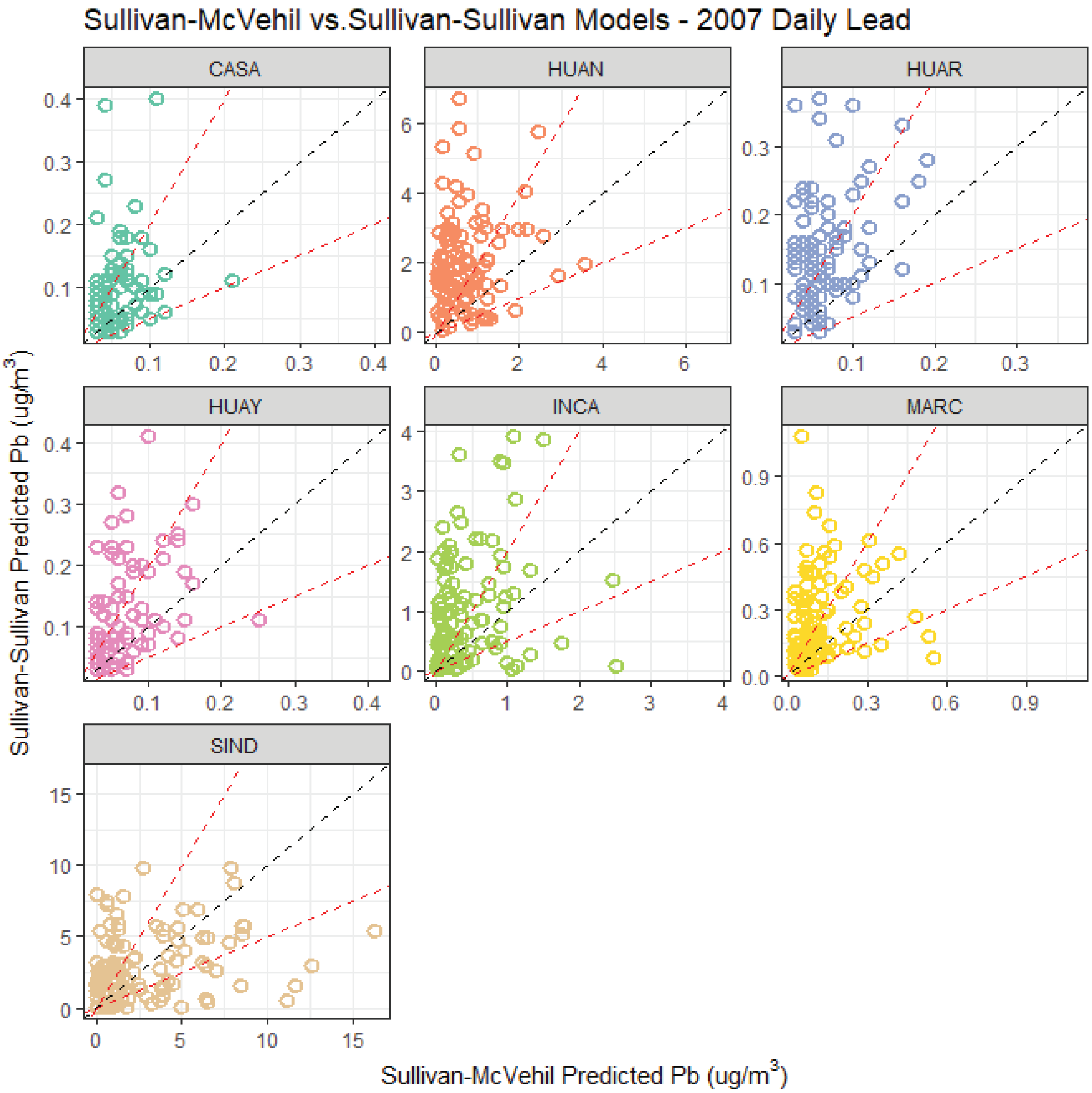

EXHIBIT 1

Table D-5. Comparison of 2007 Daily Lead Predictions based on Sullivan-Cheremisinoff versus Sullivan-McVehil Model Runs

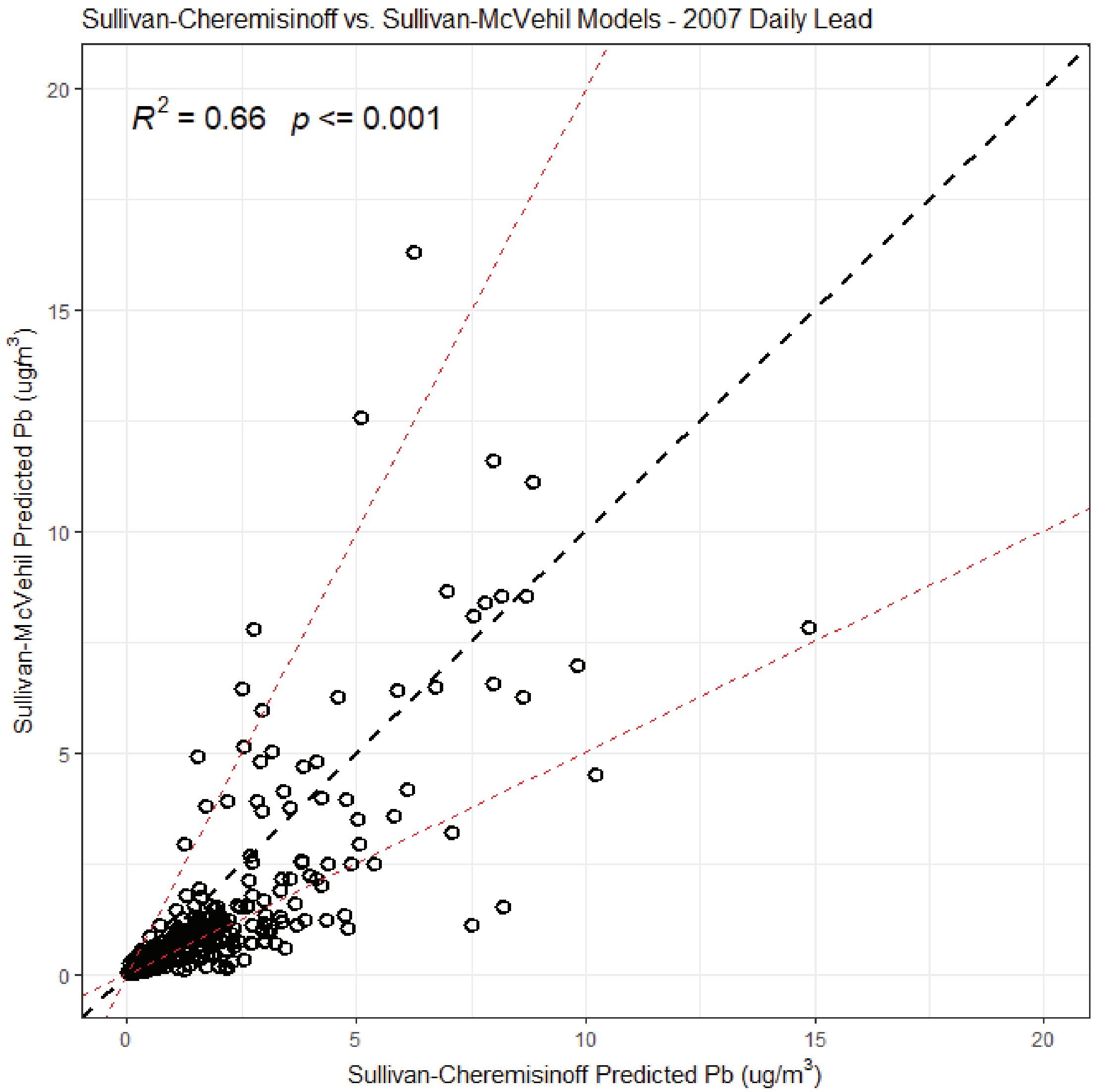

EXHIBIT 1

Table D-6. Station-specific Comparison of 2007 Daily Lead Predictions based on Sullivan-Cheremisinoff versus Sullivan-McVehil Model Runs

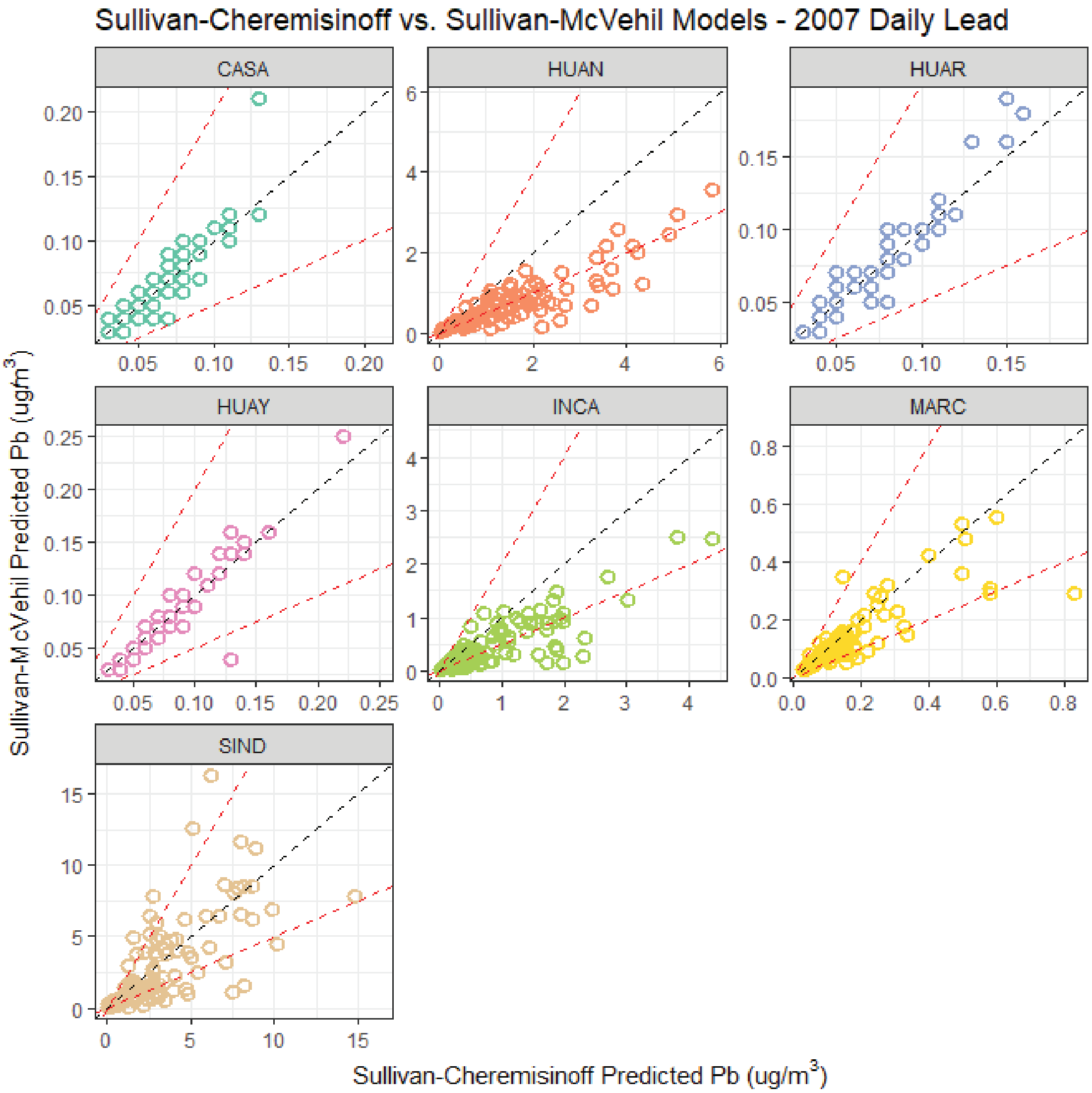

EXHIBIT 1

Table D-7. Comparison of 2007 Daily Lead Predictions based on Sullivan-McVehil (Building) versus Sullivan-McVehil (No Building) Model Runs

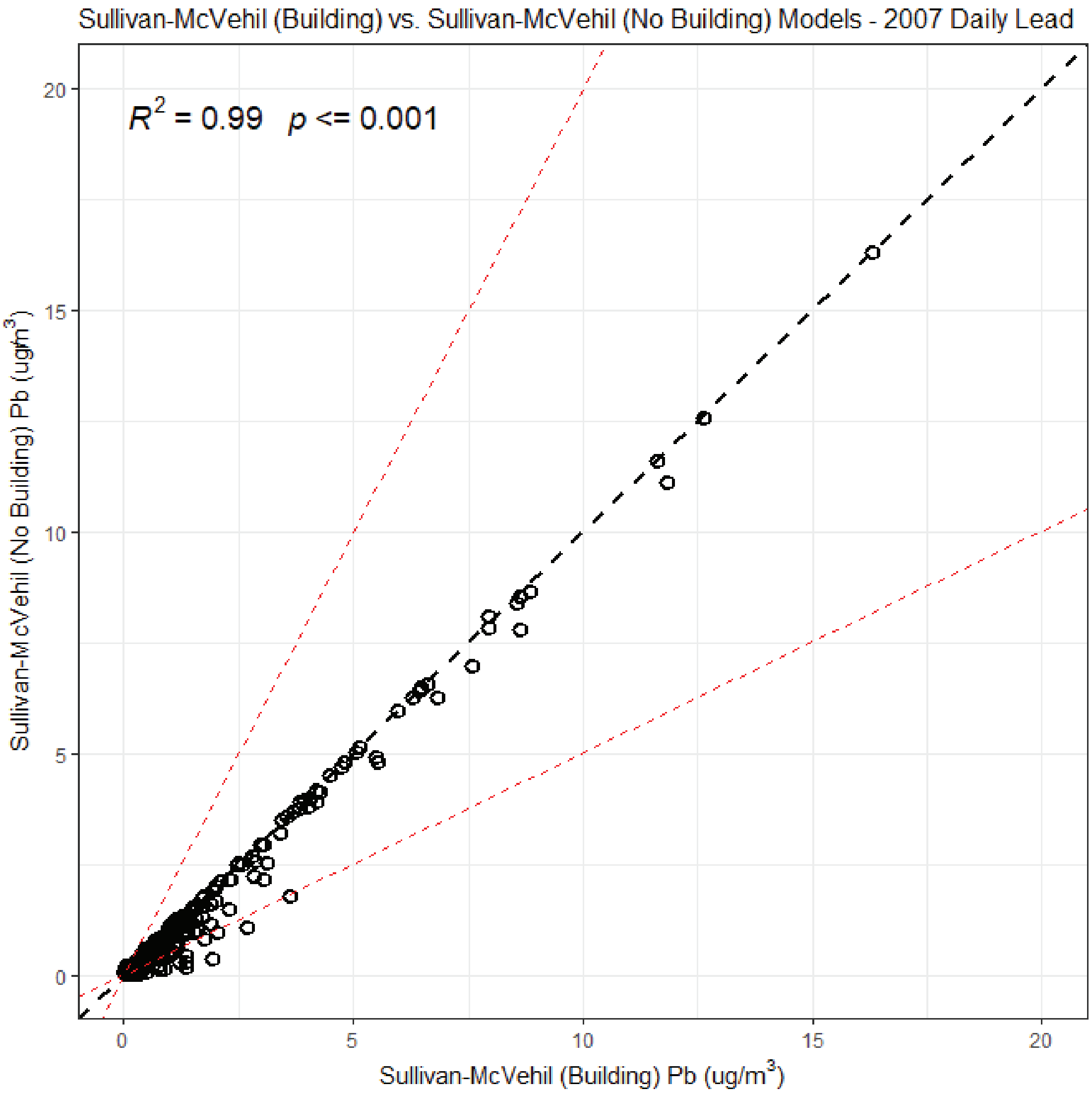

EXHIBIT 1

Table D-8. Station-specific Comparison of 2007 Daily Lead Predictions based on Sullivan-McVehil (Building) versus Sullivan-McVehil (No Building) Model Runs

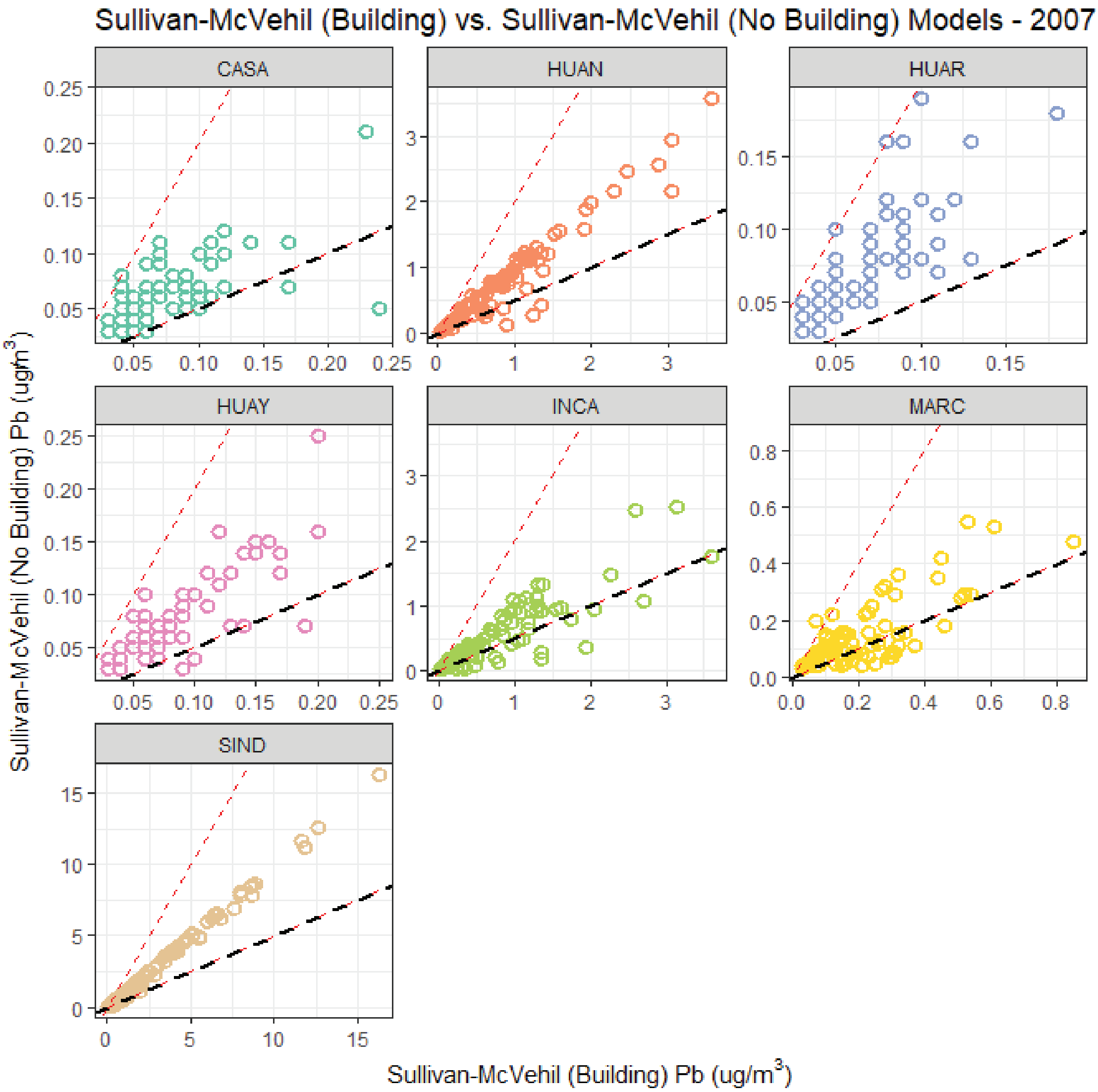

EXHIBIT 1

Concurrent Arsenic

Table D-9. Comparison of 2007 Daily Arsenic Predictions based on Sullivan-Sullivan versus Sullivan-Cheremisinoff Model Runs

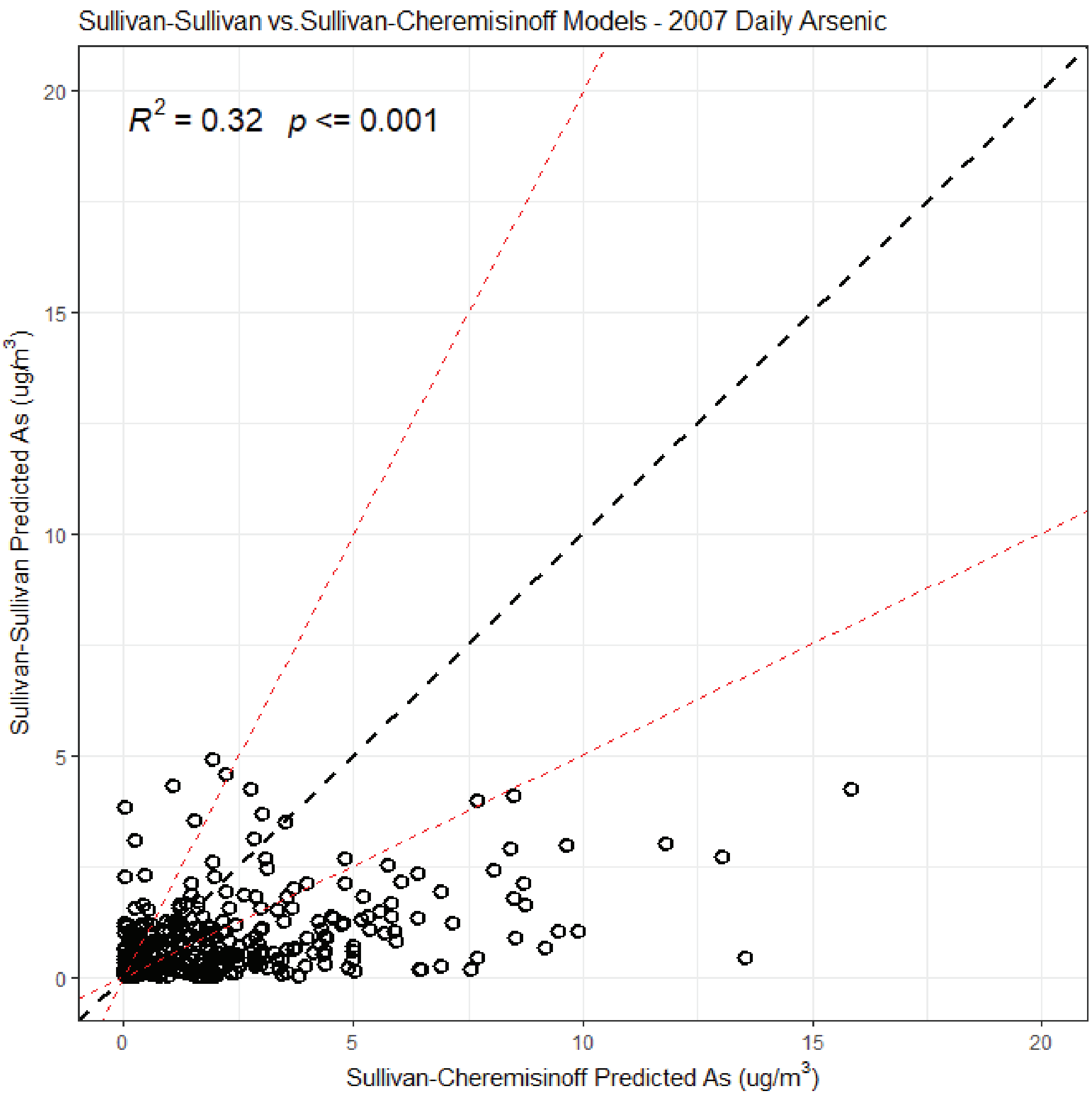

EXHIBIT 1

Table D-10. Station-specific Comparison of 2007 Daily Arsenic Predictions based on Sullivan-Sullivan versus Sullivan-Cheremisinoff Model Runs

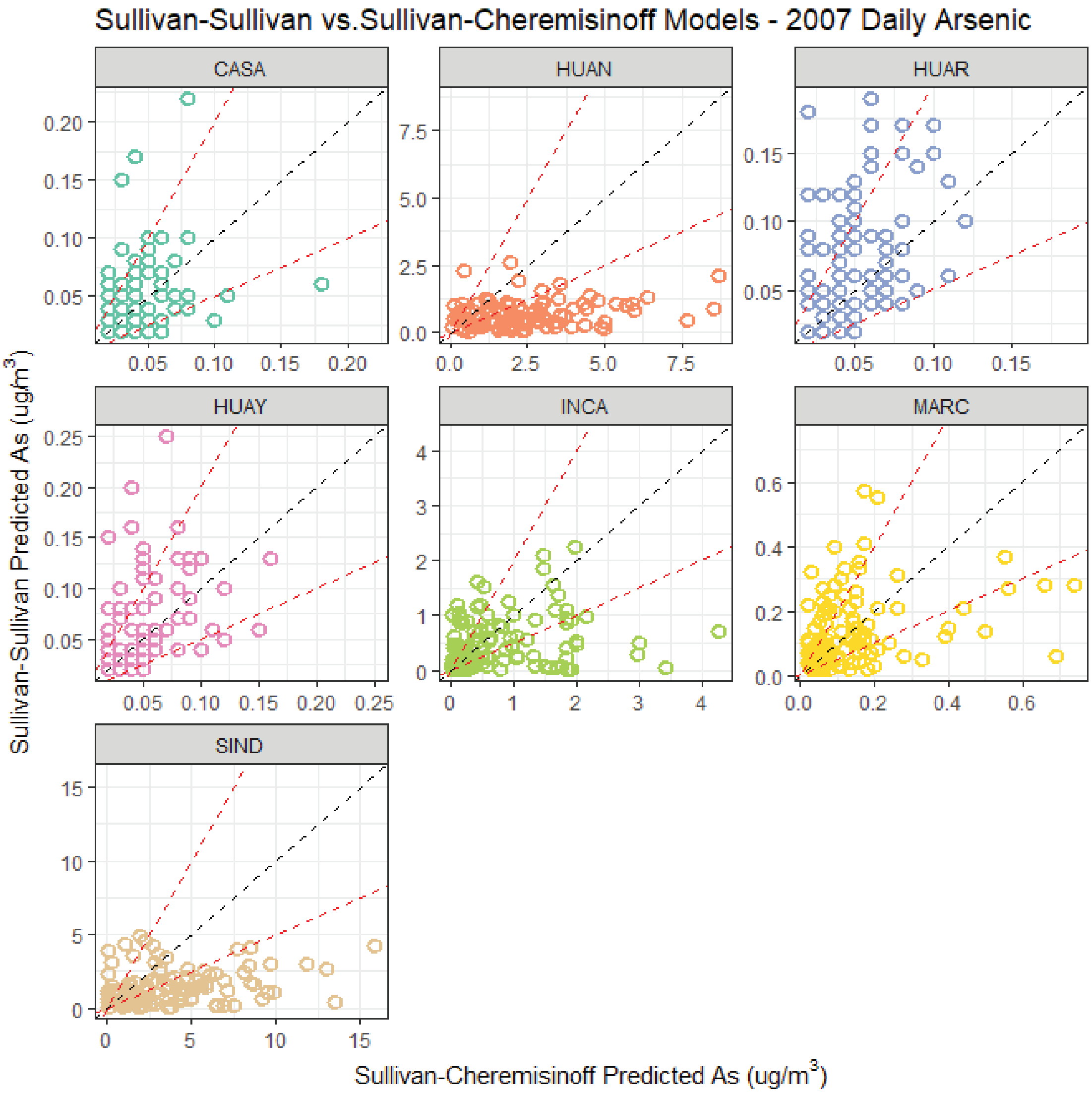

Table D-11. Comparison of 2007 Daily Arsenic Predictions based on Sullivan-Sullivan versus Sullivan-McVehil Model Runs

New run of Sullivan-McVehil for arsenic has not been provided by Mr. Sullivan.

Table D-12. Station-specific Comparison of 2007 Daily Arsenic Predictions based on Sullivan-Sullivan versus Sullivan-McVehil Model Runs

New run of Sullivan-McVehil for arsenic has not been provided by Mr. Sullivan.

Table D-13. Comparison of 2007 Daily Arsenic Predictions based on Sullivan-Cheremisinoff versus Sullivan-McVehil Model Runs

New run of Sullivan-McVehil for arsenic has not been provided by Mr. Sullivan.

EXHIBIT 1

Table D-14. Station-specific Comparison of 2007 Daily Arsenic Predictions based on Sullivan-Cheremisinoff versus Sullivan-McVehil Model Runs

New run of Sullivan-McVehil for arsenic has not been provided by Mr. Sullivan.

Concurrent SO_2

Table D-15. Comparison of 2007 Hourly SO_2 Predictions based on Sullivan-McVehil versus Sullivan-Sullivan Model Runs

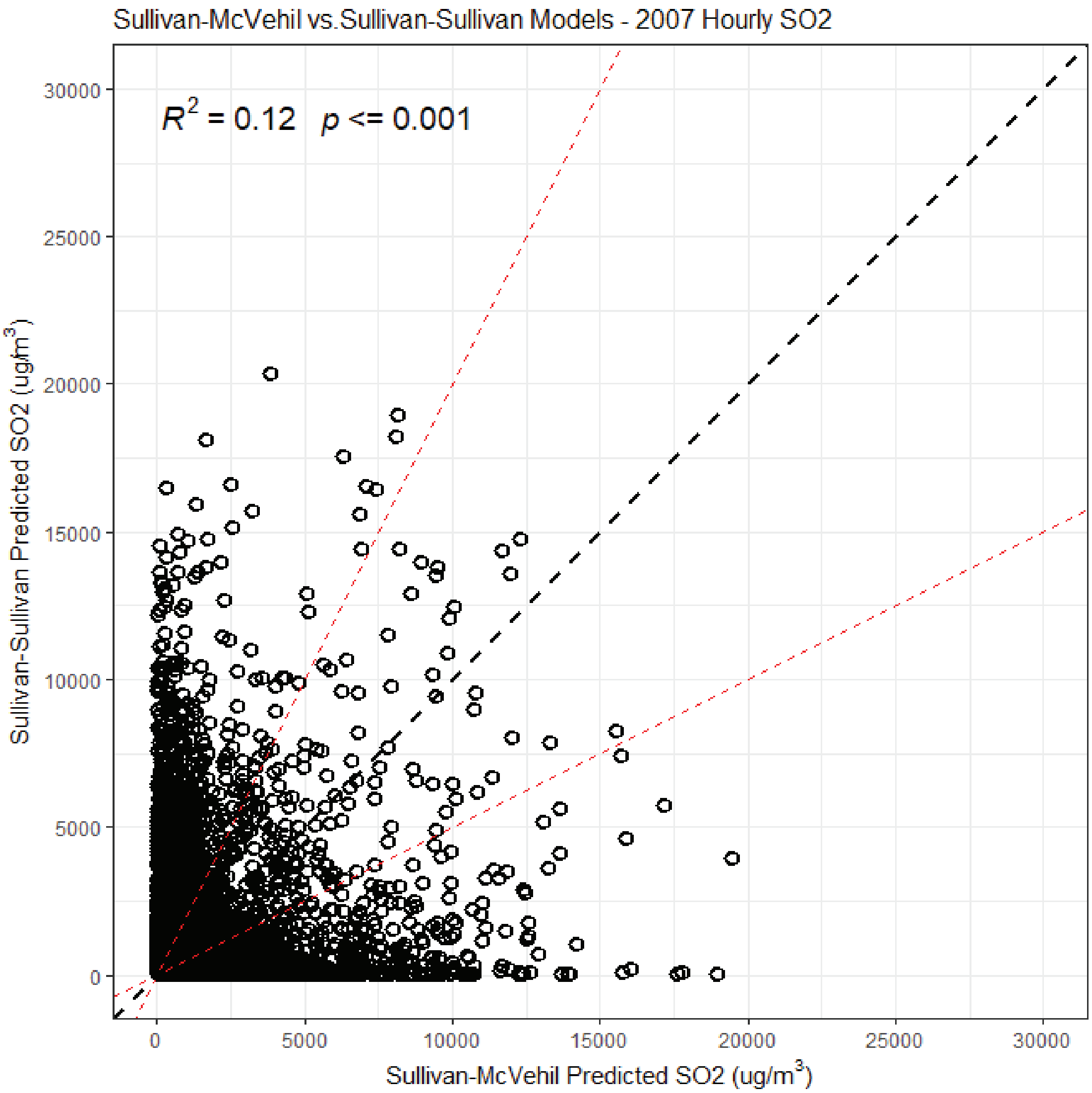

EXHIBIT 1

Table D-16. Station-specific Comparison of 2007 Hourly SO_2 Predictions based on Sullivan-McVehil versus Sullivan-Sullivan Model Runs

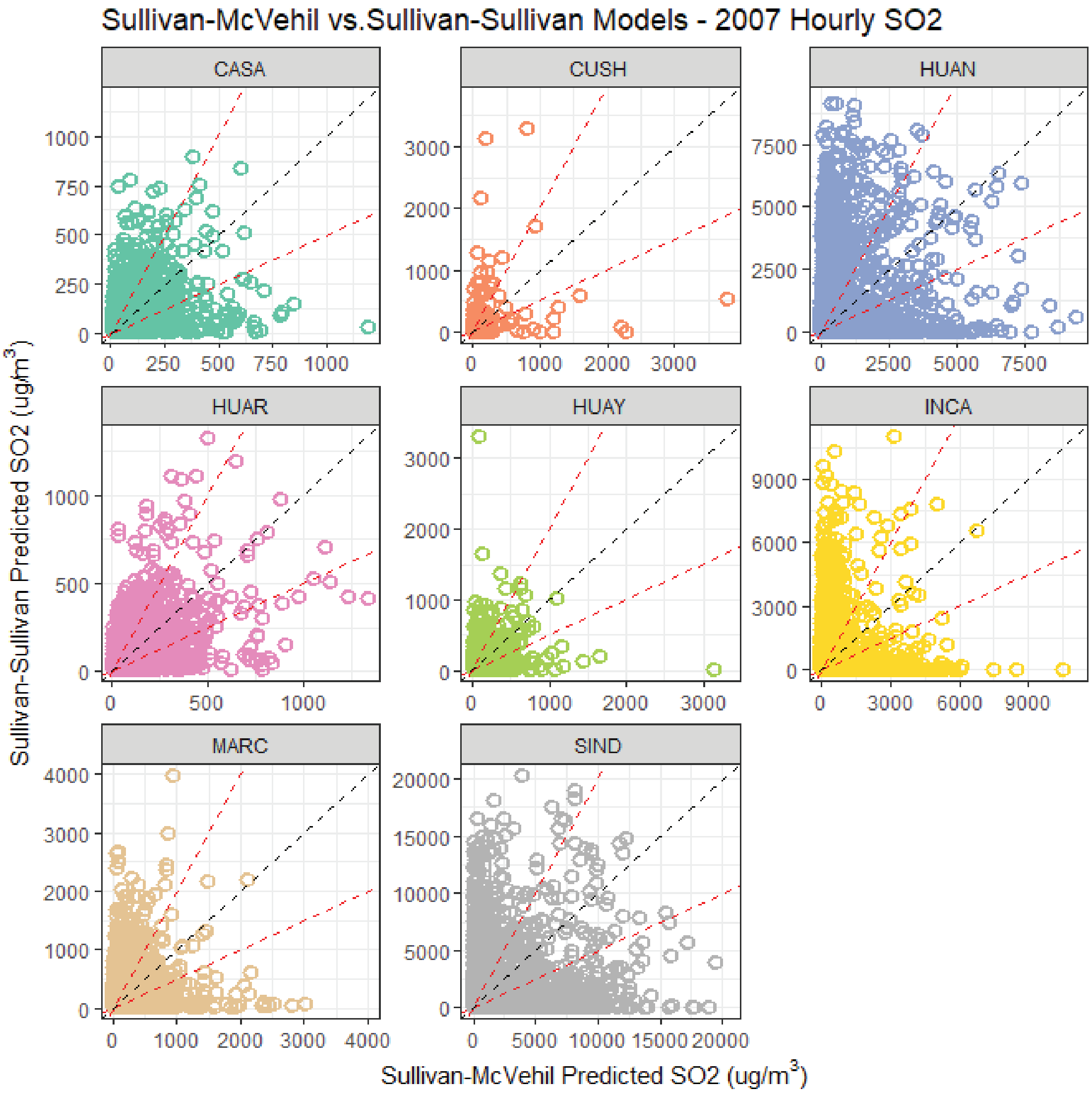

EXHIBIT 1

Table D-17. Comparison of 2007 Hourly SO_2 Predictions based on Sullivan-Cheremisinoff versus Sullivan-McVehil Model Runs

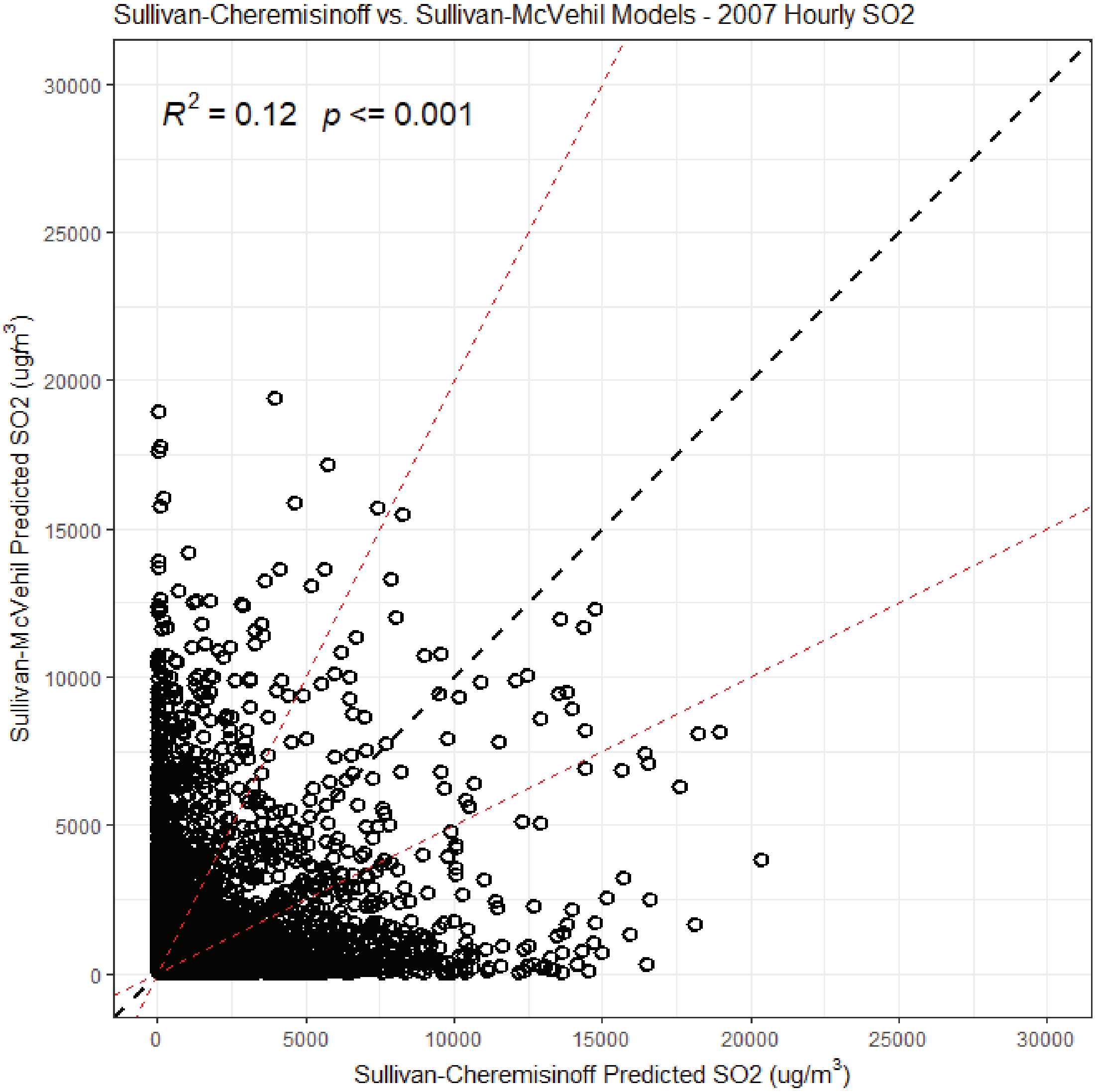

EXHIBIT 1

Table D-18. Station-specific Comparison of 2007 Hourly SO_2 Predictions based on Sullivan-Cheremisinoff versus Sullivan-McVehil Model Runs

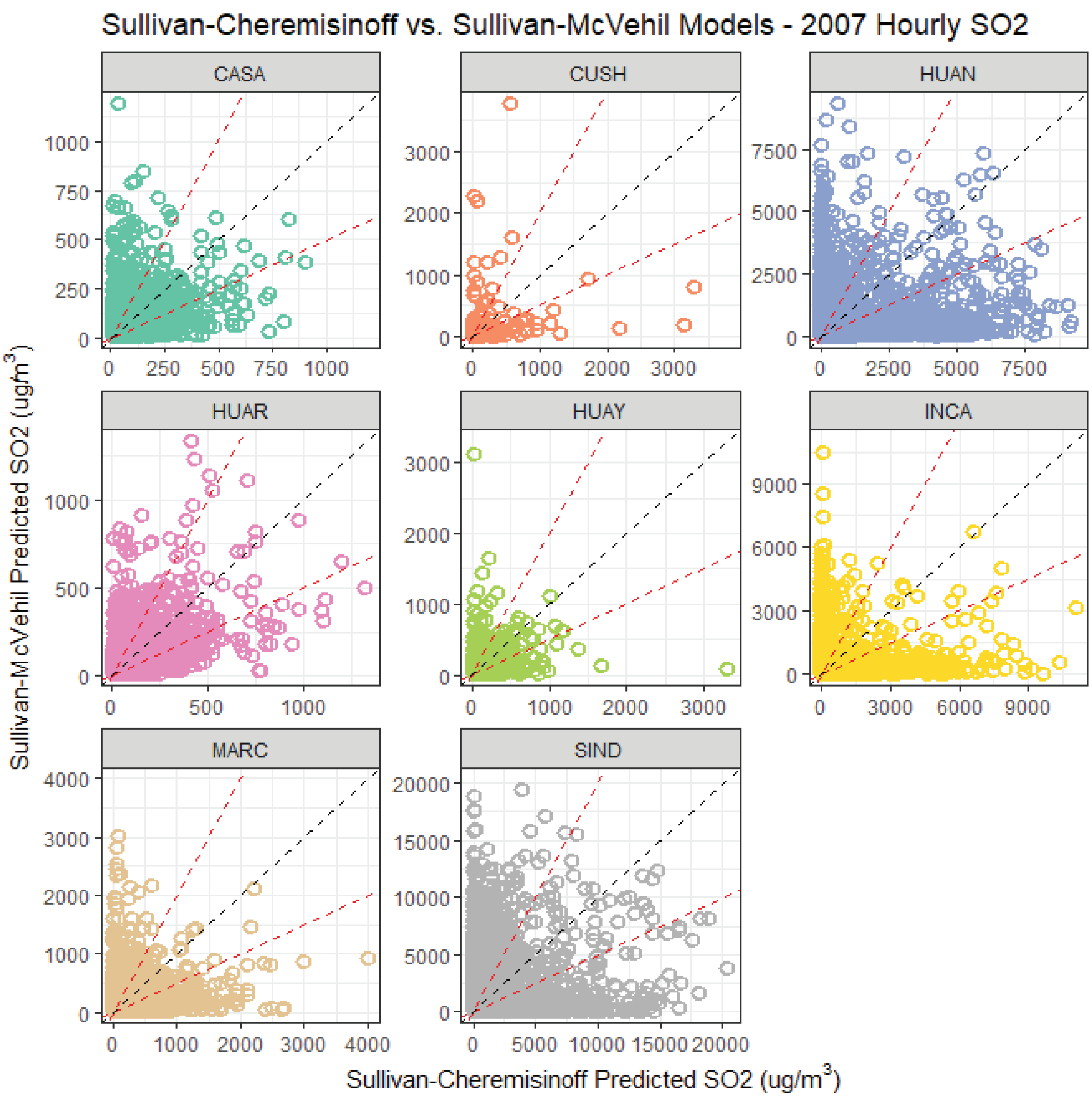

EXHIBIT 1